Fire Protection System and Life Safety Evaluation

Of

Building X

By

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Culminating Project

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Statement of Disclaimer

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Means of Egress
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Dedication

In appreciation of Prof. Frederick Mowrer, PhD, P.E.; Prof. Christopher Pascual, PhD, P.E.; Dr. David Rich, P.E.; and Dr. Christopher Lautenberger, P.E., for their dedicated efforts to obtain and convey to us students within the program decades of Fire Protection knowledge ascertained through their experiences in the academic and professional arena.

With gratitude and great appreciation to my loving and consistently supportive wife Kim, who supported me and my efforts day after day night after night to complete this Master of Science in Fire Protection Program.

Abstract
Fire Protection System and Life Safety Evaluation
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Anthony Wayne Sublett
California Polytechnic State University, 2016

The fire protection and life safety systems for Building X were evaluated for compliance in accordance with applicable nuclear power plant non-power block regulatory requirements, NEIL, INPO, IBC, and NFPA design requirements, codes, and standards. Building X is a one-story building with two internal balconies with 10 occupants per balcony, which is made of non-combustible materials that also has a partial basement with concrete walls (is normally unoccupied), which houses potable water pumps and piping for the facility. Building X falls under the definition of mixed occupancy per the International Building Code (IBC) and the Life Safety Code (LSC). Since Building X has an automatic supervised sprinkler system throughout the facility, the requirement for the building to have separated 2-hour fire resistant rated construction has been relaxed to a separation of occupancies of 1-hour fire resistant rated. Building X has a total gross building area of 75,674 SF. The highest point of the building is 28 ft. There are 15 horizontal exit discharges that serve as primary exits for a calculated building load of 970 occupants. These 15 exits are protected by either a 1 or 2-hour fire wall. However, the total building population of 970 occupants egressing through the subject 7 exits at any given time was target sample for evaluation. The fire protection and life safety systems were found to be in compliance with all the aforementioned design requirements, codes, and standards. The prescriptive requirements for occupancy classification, construction type, structural fire protection, egress systems, fire alarms, and fire protection were reviewed in great detail. The wet pipe sprinkler system in the room was evaluated and it was determined the sprinklers would actuate well before the Tenability Factors depicted below would reach levels that would render the room uninhabitable.

In addition, one fire scenario depicted below was used in a performance based fire protection analysis to validate the fire protection and life safety systems for the structure by using egress analysis and CFAST fire modeling tools. A fire scenario was selected in accordance with NFPA 101 section 5.5.3.1* which requires that a design fire that is typical for the type of occupancy and activities being performed in an area and reflects the types of fuel sources and ventilation be used as the type of design fire selected. In this scenario, an upholstered chair catches on fire in the large furnished meeting room area with one exit where the door is closed on the northeast side of the building where 18 occupants are attending a meeting. They can exit the meeting room and through one of the two exits out of the larger office area which contains 89 occupants. The dimensions for the meeting room which catches on fire that were captured in the CFAST model to determine ASET were 52 FT X 42 FT with 8 FT ceilings. An Available Safe Egress Time (ASET) was calculated for the large meeting room based on one of the following limiting tenability factors: 1) Time it takes for the soot or smoke layer to descend to 1.8 meters or 6 feet, 2) Time it takes the temperature within the room to exceed 60 Degrees Celsius, 3) time it takes the room where CO2 levels would decrease O2 levels to 12% or lower. The limiting ASET factor (tenability factor) was determined. The Required Safe Egress Time for 18 occupants traveling down one path of egress along the side of the table in the meeting room to one exit where longest travel distance is 52 FT was used to determine the following four RSET elements:
Notification time, Reaction Time, Pre-Evacuation Activity, and Travel Time. Since ASET> RSET, the large meeting room met the performance based design requirements. Using this performance-based approach, the fire and life safety systems were validated and shown to perform satisfactorily in the fire scenario presented in the report below.

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Note from the Author:
Please note since Building X is a support structure for nuclear power plant and I was new in my role as the fire protection program and system engineer much of the detailed information regarding Building X could not be disclosed for proprietary reasons.

1.0 Executive Summary

The fire protection and life safety systems for the Building X were evaluated for compliance in accordance with applicable nuclear power plant non-power block regulatory requirements, NEIL, INPO, IBC, and NFPA design requirements, codes, and standards. Building X is a one-story building with two internal balconies with 10 occupants per balcony, which is made of non-combustible materials that also has a partial basement with concrete walls (is normally unoccupied), which houses potable water pumps and piping for the facility.

Building X falls under the definition of mixed occupancy for Assembly and Business per the International Building Code (IBC) and the Life Safety Code (LSC) where in LSC sec 6.1.14.2.2 a mixed occupancy is defined as being a multiple occupancy facility where the occupancies are intermingled. Since Building X has an automatic supervised sprinkler system throughout the facility the requirement for the building to have separated 2-hour fire resistant rated construction has been relaxed to a separation of occupancies of 1-hour fire resistant rated construction in accordance with sec 6.1.14.4.3 of the Life Safety code. Therefore, Building X exceeds the requirements of separation mentioned above.

Building X has a total gross building area of 75,674 sq. ft. and the buildings highest point is 28 feet which is less than the allowable 55 feet. Per Table 503 of the IBC the maximum allowable gross area for TYPE III B construction is 23,000 square feet. However, section 506.3 allows a building area to be increased where a building is sprinkled throughout with an approved automatic sprinkler system in accordance with section 903.3.1.1 the building area limitation is permitted to be increased by an additional 300 percent for buildings with no more than one story above grade plane. A Building Overview and view of the front entrance is presented in Figure 1 and Figure 2 respectively below.

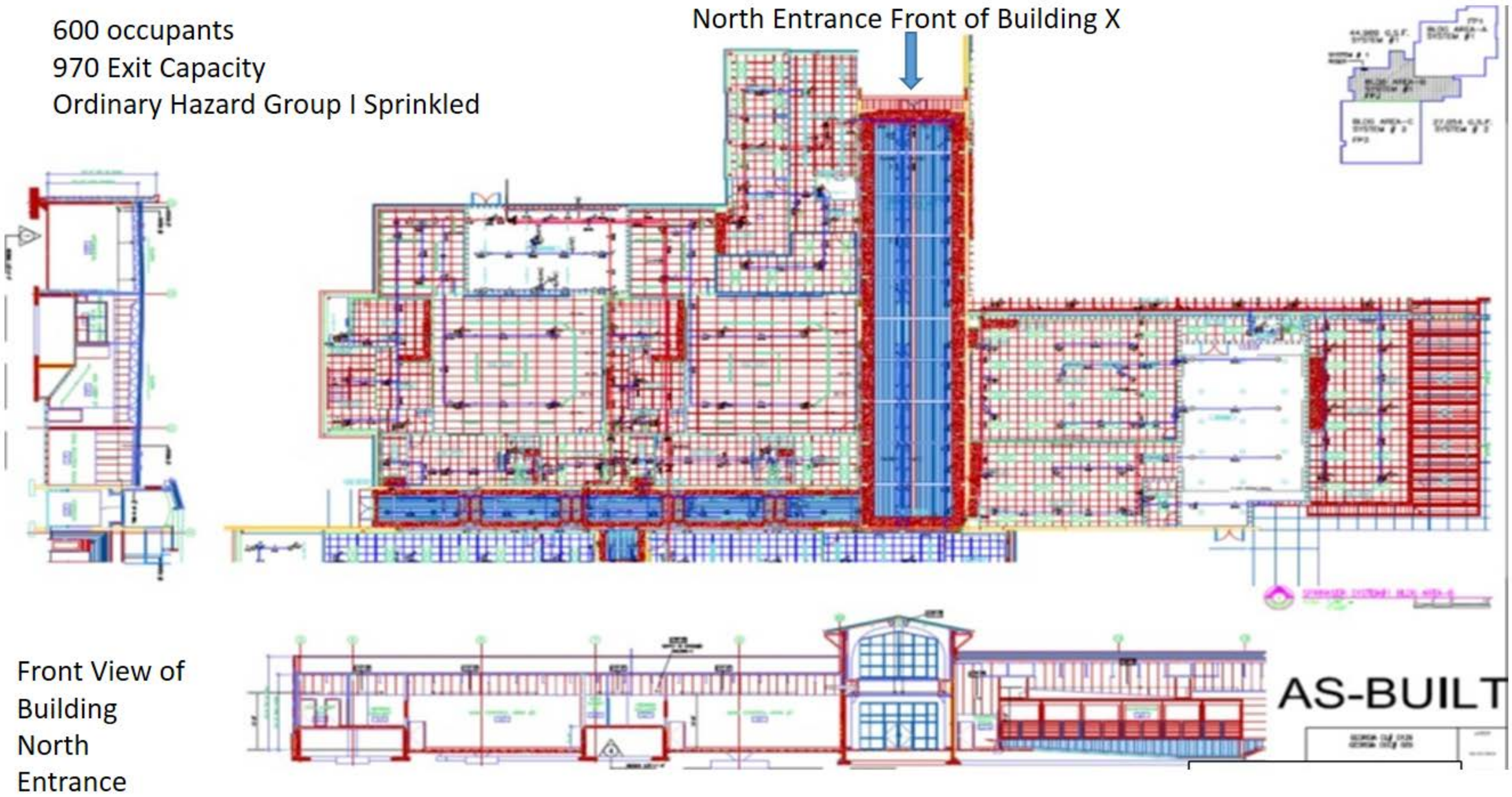

Figure 1
Building Overview

Construction:

- Exterior Walls made of Non-combustible materials
- One Story building with two internal balconies with an occupancy capacity of 10
- Both Sets of internal balconies have 2 hour fire walls that protect their vertical openings

Front (North) Entrance to Main Corridor:

Figure 2
Front North Entrance

There are 15 horizontal exit discharges (highlighted in yellow shown in Figure 3 below on page 14) that serve as primary exits for a calculated building load of 970 occupants. These 15 exits are protected by either a 1 or 2-hour fire wall. However, the total building population of 970 occupants egressing through the subject 7 exits (also shown in Figure 3) at any given time was the target sample used for evaluation.

The fire protection and life safety systems were found to be in compliance with all the aforementioned design requirements, codes, and standards. The prescriptive requirements for occupancy classification, construction type, structural fire protection, egress systems, fire alarms, and fire protection were reviewed in great detail. The wet pipe sprinkler system in the large meeting room was evaluated and determined the sprinklers would actuate in 4.04 minutes, which is well before the Tenability Factors depicted below would reach levels that would render the room uninhabitable.

In addition, one fire scenario depicted below was used in a performance based fire protection analysis to validate the fire protection and life safety systems for the structure by using egress analysis and CFAST fire modeling tools. A fire scenario was selected in accordance with NFPA 101 section 5.5.3.1* which requires that a design fire that is typical for the type of occupancy and activities being performed in an area and reflects the types of fuel sources and ventilation be used as the type of design fire selected. In this scenario, an upholstered chair catches on fire in the large furnished meeting room. This meeting room has one exit where the door is closed. There are 18 occupants attending a meeting in this large meeting room. They can exit the meeting room through one of the two exits out of the larger office area which contains 89 occupants. The dimensions for the meeting room which catches on fire that were captured in the CFAST model to determine ASET were 52 FT X 42 FT with 8 FT ceilings. An Available Safe Egress Time (ASET) was calculated for the large meeting room based on one of the following limiting tenability factors: 1) Time it takes for the soot or smoke layer to descend to 1.8 meters or 6 feet, 2) Time it takes the temperature within the room to exceed 60 Degrees Celsius, 3) time it takes the room where CO2 levels would decrease O2 levels to 12% or lower. The limiting ASET factor (tenability factor) that was reached by CFAST was the time at which Visibility Level reached 6 feet or 1.8 m which was 520 seconds (8.6 minutes).

The Required Safe Egress Time for 18 occupants traveling down one path of egress along the side of the table in the meeting room to one exit where longest travel distance is 52 FT was used to determine the following four RSET elements:
Notification time of 10 seconds plus Reaction Time of 30 seconds plus Pre-Evacuation Activity Time of 30 seconds plus Travel Time of 13.24 seconds = **83.2 seconds**
It was then determined since ASET> RSET= 520 seconds > 83.24 seconds the large meeting room met the performance based design requirements.

Since the limiting ASET factor calculated by CFAST was the Tenability Limit for Time at which Visibility Levels reached 6 feet or 1.8 m was 520 seconds, automatic sprinkler detectors will take 4.04 min to actuate, and RSET for the large meeting room was 62.4 seconds the life safety and fire protection systems were deemed as being adequate.

2.0 Regulatory Requirements:
Building X is required to meet either the prescriptive requirements or performance-based goals and objectives to be in compliance with NEIL (the insurance agency that provides coverage for all unit power block and support structures like Building X) requirements. Again based on the analyses depicted in the LSC, Building X meets both the prescriptive life safety requirements as well as the performance-based goals and objectives defined in the LSC.

<u>Code of Record:</u>
The code of record for Building X is the September 2010 NEIL Loss Controls Standards which supersedes but in most instances references the NFPA requirements. The NEIL Loss Controls Standards defines the regulatory and or code requirements to which the fire protection systems will be designed, built, maintained and inspected in accordance too. In most instances the NEIL Loss Controls Standards defers to applicable NFPA codes.
In addition, the IBC 2006 edition, LSC 101 2009 edition, NFPA 72 2010 edition, NFPA 13 2010 edition, NFPA 20 2009 edition, and NFPA 25 2009 edition are referenced as applicable code of records. The IFC

2012 edition was used to provide guidance for maintaining the operating systems and fire safety during the construction and demolition and destruction phase. The IFC and the provisions it contains was not considered or used as regulatory document.

Authority Having Jurisdiction:
Since Nuclear Electric Insurance Limited (NEIL) insures all support (i.e. Building X) and power block structures, NEIL serves as the primary authority having jurisdiction (AHJ). In addition, the Institute of Nuclear Power Operations (INPO) and the Nuclear Regulatory Commission (NRC) serve as secondary AHJs. Since this is a support structure for the nuclear facility located in Waynesboro Georgia the state fire Marshall is not the cognizant fire code authority or AHJ.

3.0 Background
A single source fire was assumed when performing the egress evaluation and developing the fire protection system design [Ref: 1].
This report will first address the fire protection prescriptive requirements as defined in NFPA 101, Life Safety Code (LSC) [Ref:1] followed by some performance-based criteria of NFPA 101, Life Safety Code (LSC) [Ref 1] in its limited application to Building X. The purpose of the LSC is to provide minimum fire protection requirements in terms of design, operation, and maintenance of buildings and structures for safety for life from a fire [Ref: 2].
Goals for Fire Protection System:
The following two goals set forth in the life safety code provided concise deliverables that were achieved by the Fire Protection System Design Objectives listed below:

1. Protection of occupants not intimate with the initial fire development
2. Improvement of the survivability of occupants' intimate with the initial fire development [Ref: 1].

Fire Protection System Design Objectives:
Detection, alarm, suppression, and egress were the four primary areas of fire protection that were addressed with respect to achieving the following objectives:

1. A structure shall be designed, constructed, and maintained to protect occupants who are not intimate with the initial fire development for the time needed to evacuate, relocate, or defend in place.

2. Structural integrity shall be maintained for the time needed to evacuate, relocate, or defend in place occupants who are not intimate with the initial fire development.

3. Systems utilized to achieve the goals of Section 4.1 of the LSC shall be effective in mitigating the hazard or condition for which they are being used, shall be reliable, shall be maintained to the level at which they were designed to operate, and shall remain operational [Ref: 1] [Ref: 7].

Performance Criteria and Design Attributes:
In general, nuclear facilities gear their fire protection program towards protection of property as the primary objective and protection of personal as the secondary objective. Given the heightened visibility brought to the NRC by the public and anti–nuclear organizations regarding inadequacies of fire protection programs in nuclear power plant facilities close to 50% of the nuclear power plants have begun to upgrade their fire protection program and systems to NFPA 805 Performance Based Fire Protection. However, since NEIL's primary concern is protection of property, efforts to promote life safety in fire protection system design and fire protection program implementation often fall by the way side. In addition, previous egress systems and pre-fire plans for nuclear facilities were based on the theory that the building and equipment would be abandoned in place opposed to defense in depth fire protection program design measures which are geared towards performance based design for fire protection and fall in line with NFPA 805 objectives that power plants are currently being upgraded in accordance with.

The following performance attributes, which are defined in the NFPA handbook for life safety that also parallel the protection of property objectives for nuclear fire protection requirements defined in the NEIL requirements, were both taking into account with the design of Building X's fire protection system and development of relative egress procedures [Ref: 2, pg. 4-73]:

1. Sufficient number of properly designed, unobstructed means of egress of adequate capacity and arrangement
2. Provision of alternative means of egress for use if one means of egress is blocked by fire, heat or smoke
3. Protection of the means of egress against fire, heat, and smoke during the egress time determined by the occupant load, travel distance, and exit capacity
4. Subdivision of areas by proper construction to provide areas of refuge in those occupancies where total evacuation is not a primary consideration
5. Protection of vertical openings to limit the operation of fire protection equipment to a single floor
6. Provision of detection of alarm systems to alert occupants and notify the fire department in case of fire
7. Adequate illumination of the means of egress
8. Proper marking of the means of egress and the indication of directions
9. Protection of equipment or areas of unusual hazard that could produce a fire capable of endangering the egressing occupants.
10. Initiation, organization, and practice of effective drill procedures
11. Provision of instructional materials and verbal alarm systems in high-density and high-life hazard occupancies to facilitate adaptive behavior
12. Use of interior finish materials that prevent a high flame spread or dense smoke production that could endanger egressing occupants

The fire protection system was designed to satisfy the ***Systems Effectiveness*** and provided the facility with a reliable system those possess the ability to mitigate a fire hazard [Ref: 1 sec 4.2.3].

This report satisfies the provision of a documented prescriptive analysis as depicted in NFPA 101 [Ref 1] [Ref: 7]. Non-compliances would be documented and a recommendation made for either requesting an equivalency from the Authority Having Jurisdiction (AHJ) or identifying additional compensatory measures to mitigate the adverse consequences of fire. All equivalencies were reviewed, approved, and documented in accordance with NFPA 101 sect 1.4 [Ref: 1] [Ref: 7].

The design was reviewed against IBC 2006 edition, LSC 101 2009 edition, NFPA 13 2010 edition, NFPA 20 2009 edition, NFPA 25 2009 edition. All acceptance test and design reviews were conducted and documented in accordance with the applicable codes. The result of these tests was excluded from this document since they were not the objective of this report.

4.0 Prescriptive Analysis

4.1 Building X Design Intent

The building orientation shown in The Egress Floor Plan in Figure 3 below depicts the building orientation as the top of the page is north, right hand side of page is east, left hand side of page is west, and bottom of page is south. Building X was built as a support structure for the new nuclear power electrical generating plant for Southern Nuclear Company's located in Waynesboro Georgia. It was designed and built in accordance with the International Building Code 2006, NFPA101 (no edition was specified) OCGA 120-3-3, and OCGA 120-3-20 and is classified as a TYPE III B Fully Sprinkled Building Per section 602.3 of the IBC. Type III B have the following fire resistance requirements for its building elements as depicted in Table 601 of the IBC 2009 edition [Ref:8].

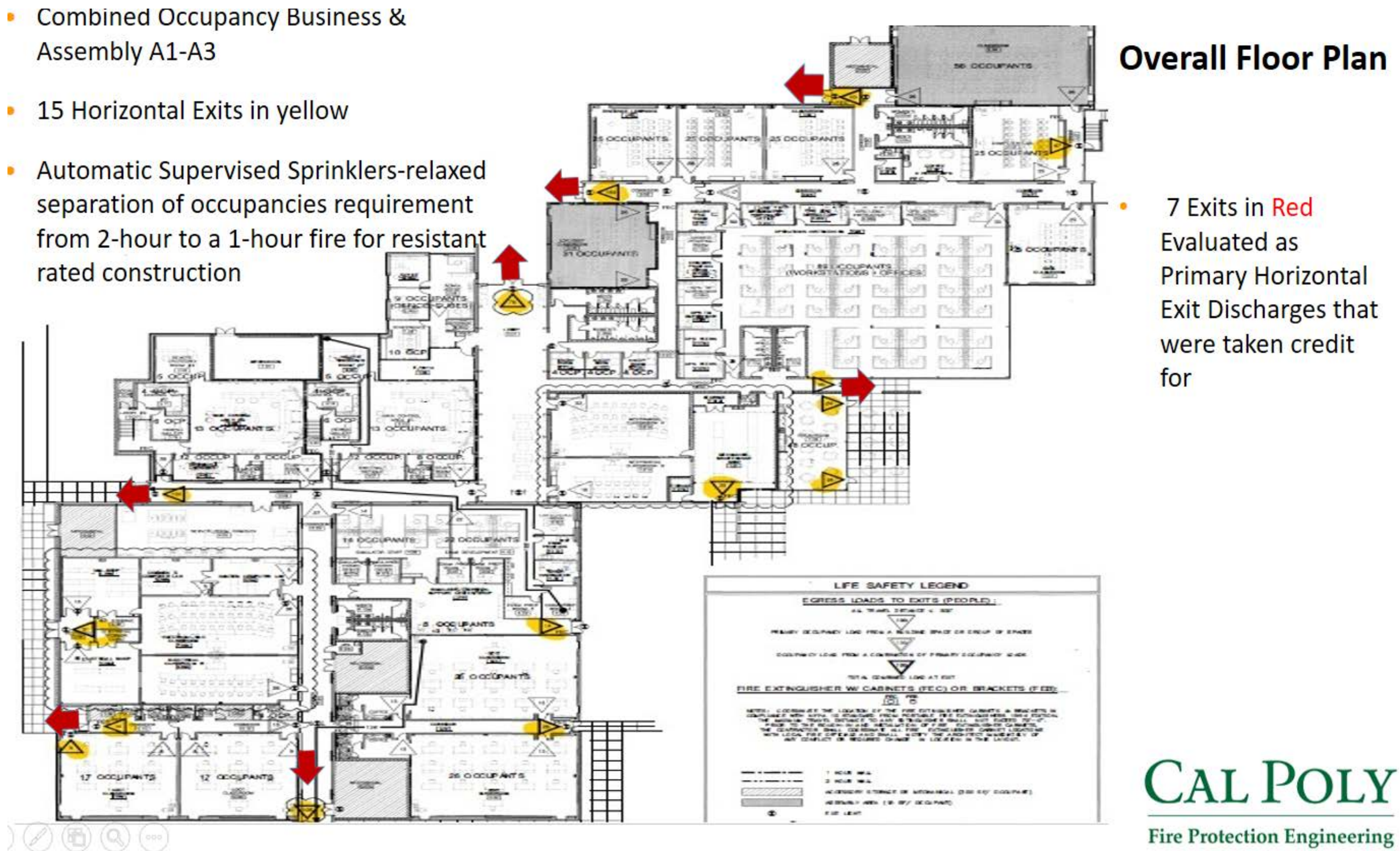

Figure 3
Egress Floor Plan

4.2 Construction
Building X is a one-story building with two internal balconies with 10 occupants per balcony, which is made of non-combustible materials that also has a partial basement with concrete walls (is normally unoccupied), which houses potable water pumps and piping for the facility. Building X is considered a Type IIB construction in accordance with section 602.3 of the IBC given that its exterior walls are made of non-combustible materials and the interior walls (the atrium) are made of some combustible materials.

Building elements requirements for this TYPE III B Fully Sprinkled Building per section 602.2 of the IBC [Ref:4] are listed in Table 1 below:

Table 1 Type III B Fire Resistance Requirements for Building Elements

	TYPE B	
Building Element	A	B
Primary Structural Frame	1	0
Exterior Bearing Walls	2	2
Interior Bearing Walls	1	0
Non-Bearing Walls and Partitions Exterior	See IBC Table 602	
Non-Bearing Walls and Partitions	0	0
Floor Construction and Secondary Members	1	0
Roof Construction and Secondary Members	1	0

Per section 705.2 of the IBC Building X overhangs, eaves, exterior balconies, and similar projections that extend beyond the exterior walls of the building have been constructed in accordance with section 1406 of the IBC. The one exterior egress balcony, egress stairs, and remap on the east side have been built in accordance with section 1019 and section 1026 of the IBC. Where section 1019 of the IBC states that balconies used for egress purposes shall conform to the same requirements as corridors for width, head room, dead ends, and projections [Ref:8]. There are two sets of interior stairs that go up to the balcony, the partial basement is accessed through an external door down at the basement location (building is orientated on a hill). Since both sets of internal stairs have 2-hour fire walls that protect their vertical openings their construction exceeds the requirements of the LSC Table 8.3.4.2 by requiring a 1-hour minimum protection rating [Ref:1]. The stairway construction satisfies the following LSC requirements for section 7.2.2.5.1 Enclosures. 7.2.2.5.1.1 All inside stairs serving as an exit or exit component shall be enclosed in accordance with 7.1.3.2. 7.2.2.5.1.2 Inside stairs, other than those serving as an exit or exit component, shall be protected in accordance with Section 8.6.

The Fire Resistance Rating for Exterior Walls based on the separation distance for this combined Assembly and Business occupancy building per Table 602 of the IBC [Ref:4] are listed in Table 2 below:

Table 2 Fire Resistance Rating for Exterior Walls

Fire Separation Distance	Type of Construction	Occupancy Group A&B
30<or =X	III Group B	0 HRS

Exterior Walls were constructed in accordance with 704 of the IBC [Ref: 8].
Per section 704.2; Projections, 704.2.1 of the IBC Type I and Type III Construction. Projections from walls of Type I or Type III construction shall be of non-combustible materials as allowed per section 1406.3 and 1406.4 [Ref:4].
Exterior wall projections consist of tilt-up concrete panels.
The Maximum Area of Exterior Wall Openings per Table 704.8 of the IBC [Ref: 8]

Table 3 Maximum Area of Exterior Wall Openings

Classification of Opening	**Fire Separation Distance (Greater than 15' to 20') (15'-6" Provided)**
Unprotected (Existing Building)	25% MAX > Approx. 14 on Existing Building
Protected (New Building)	75 % Max > Approx 5 % on New Building

The Limited Sizes of Wired Glass Panels per Table 715.5.5.3 of the IBC [Ref: 8].

Table 4 Limited Sizes of Wired Glass Panels

Opening Fire Protection Rating	Max Area	Max Height	Max Width
1 hr.	100 sq. in.	33 in.	10 in.

Actual Building Construction:
The only required area of the building requiring a rating is the interior corridor which requires a 1-hour rating. The corridor extends from the floor to the bottom of the floor above or the bottom of the roof deck. All opening including doors, glass and any penetrations for pipe or ductwork must maintain the rating.

Actual Building Construction Materials:
Roof Construction:
Metal deck with insulation and built-up roofing above. Metal beams and framing.

Structure:
Metal construction consisting of various columns, beams, girders and joists of metal construction.

Walls (Interior and Exterior):
Exterior Walls:
6” metal studs at 16” O.C. with R-19 insulation. Exterior cement with plaster lath. Interior varies per room finish schedule.

Interior Walls (non-rated):
6” metal studs at 16” O.C. with sound batt insulation. Finish varies per room finish schedule.
Fire-Retardant-treated wood framing wood framing that complies with IBC section 2303.2 installed inside the atrium or main hallway that runs north to south throughout the building.

Rated Constructions:
Interior Walls (1-hour rated):
6” metal studs at 16” O.C. with sound batt insulation. 5/8” type “x” gyp. Bd. On each side.
Interior Rated Corridor – wall and ceiling tunnel (1-hour rated):
6” metal studs at 16” O.C. with sound batt insulation. 5/8” type “x” gyp. Bd. On each side.
Rated Shaft at Elevator (1-hour rated):
USG Steel Studs at 24” O.C. 5/8” type “x” gyp. Bd. On each side.

4.3 Occupancy, Use, and Occupant Characteristics
Building X is used as a support structure with a classified occupancy for business and assembly (A-/ A-3 per the IBC) and is used in support of the nuclear power plant, which is under construction. This building is considered to be mixed occupancy therefore per section 302.1 each portion of a building shall be individually classified in accordance with section 305.2 of the IBC. Please see Figures 4 and 5 below on page 17 for an Occupancy Overview. Where a building contains more than one occupancy group, the building or portion thereof shall comply with section 508.3.1, 508.3.2, 808.3.3 or a combination of these respective sections[Ref:4]. For a mixed occupancy, the LSC requires the application of the most restrictive requirements per LSC section 6.1.14.
This building also falls under the definition of mixed occupancy in LSC sec 6.1.14.2.2 where a mixed occupancy is defined as being a multiple occupancy facility where the occupancies are intermingled.
Per table 6.1.14.1(b) of the LSC the two occupancies must be separated 2-hour fire resistant rated construction. However, since the entire building has an automatic supervised sprinkler system this requirement has been relaxed to a separation of occupancies by a 1-hour fire resistant rated construction in accordance with sec 6.1.14.4.3 of the life safety code which is previously illustrated in the Egress Floor Plan in Figure 3 [Ref:1]. Therefore, Building X exceeds the requirements of separation mentioned above.

Figure 4
Occupancy Overview Top Section of Floor Plan

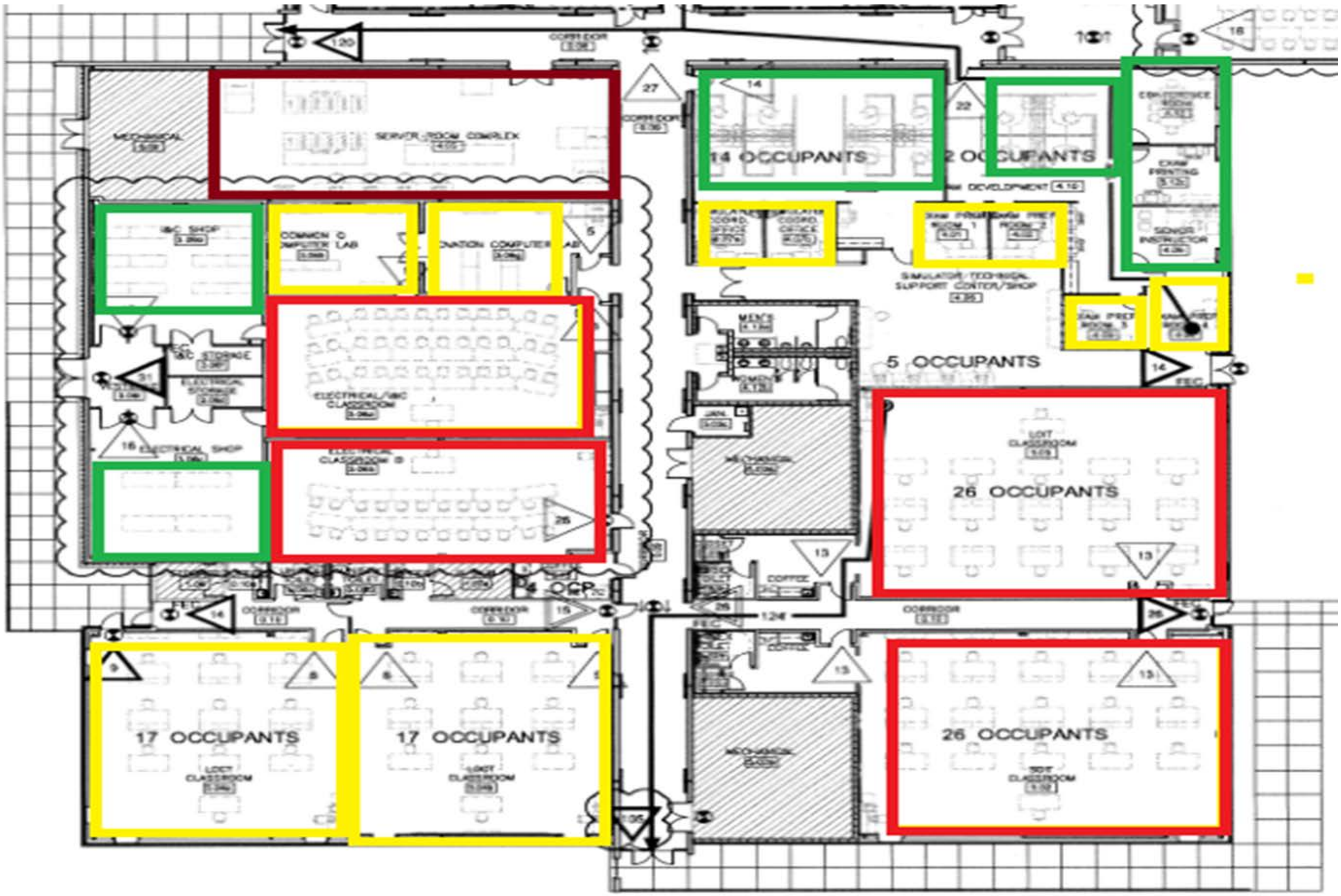

Figure 5
Occupancy Overview Bottom Section of Floor Plan

Building X has a total gross building area of 75,674 square feet and the buildings highest point is 28 feet which is less than the allowable 55 feet. Per Table 503 of the IBC the maximum allowable gross area for Type III B construction is 23,000 square feet. However section 506.3 allows a building area to be increased where a building is sprinkled throughout with an approved automatic sprinkler system in accordance with section 903.3.1.1 the building area limitation is permitted to be increased by an additional 300 percent(I_s =3) for buildings with no more than one story above grade plane(which is the case since Building X is a single story building with a height of 28 feet which is less than 55 foot limit designated in Table 503 of the IBC [Ref:4]. Thus it can be assumed that a calculation increase per section 506.3 of the IBC has been performed for rooms that exceed the allowable gross area of 23,000, but since this subject is beyond the scope of this project those calculation details have been omitted from this report. However, this gross area room increase will play a key role in the increase in occupant loads calculated in appendix B. Personal that occupy this facility are highly trained and participate in quarterly announced and unannounced drills as required by NEIL (note, the NRC is not the partial AHJ for this structure since it is a support non power block building). This training has a positive effect on the delay times as mentioned in section 7.2 Factors Affecting Tenability Performance below. IBC Table 1004.1.1 provides an occupant load of 15 feet per person for assembly un-concentrated use without fixed seating and 100 square feet per person for business use. Since the building would have an unlimited number of accounts where mixed occupancy would occur the occupant load factor of 100 square feet per person was used (see Appendix B [Ref: 4].

EGRESS ANALYSIS

Occupant Loads

1. ACTUAL OCCUPANT LOADS = Respective calculated loads rounded up to the next hole number.

2. OLF gross was used for all occupancy classifications depicted below except for the shop.

Assumptions: Taking into account Building X is a new facility furniture placement was unknown in conference rooms and the gross area for all areas was used.

TABLE 5 Floor Occupancy Loads

			Per IBC Table 1004.1.1			LSC Sec 7.4.1.2		
Floor	**Space Occupancy Classification**	**GROSS AREA OF SPACE SQ FT**	**OCCUPANT LOAD FACTOR**	**CALCULATED OCCUPANT LOAD FOR SPACE BASED ON GROSS AREA**	**CALCULATED OCCUPANT LOAD FOR SPACE ROUNDED UP TO WHOLE #**	**# of Required Exits**	**Actual # of Exits/Door designator (**See red arrows Figure 3)	**Actual Capacity**
1st Floor	Business	63291	100	632.91	632	3	7	91
1st Floor	Assembly(un-concentrated)	8448	15	563.2	564	3	7	33
1st Floor	Mechanical Maintenance Shop	2779	50	55.58	56	2	3	25
Balcony A Second Fl	Assembly(concentrated)	289	7	41.28	42	1	EA ID 1 (1 DOOR PROVIDED)	4
Balcony A Second Fl	Assembly(concentrated)	289	7	41.28	42	1	EA ID 2 (1 DOOR PROVIDED)	6
Balcony B Second Fl	Assembly(concentrated)	289	7	41.28	42	1	EA ID 3 (1 DOOR PROVIDED)	4
Balcony B Second FL	Assembly(concentrated)	289	7	41.28	42	1	EA ID 4 (1 DOOR PROVIDED)	6

TABLE 5 Floor Occupancy Load Totals:

Total Area Gross square feet	**75674**
Occupant load for 1st floor	**950**
Balcony levels A+B = 20	**20**
Total occupant load	**970**

Assumptions:

1. Occupants will use closest exit access, exit, and exit discharge.
2. Occupants are distributed in a balance occupant load as depicted previously in the Egress Floor Plan in Figure 3
3. All occupants will evacuate at the same time when audible alarm is actuated.
4. The Specific flow of 175 people/ft. will be the max flow

Egress Capacity

A. The occupant load capacity that has to be met that accesses the exit discharge doors depicted in Table 6 below are inscribed inside triangles previously illustrated in the Egress Floor Plan in Figure 3. The bold triangles (highlighted in yellow) position directly in front of the exit discharge doors and are also positioned directly in the path of the horizontal exit.

B. ACTUAL EGREES CAPACITY = Respective egress capacity rounded down to the next whole number.

C. The required corridor capacity = total actual load /actual number of exits

D. If exit capacity for the area is greater than the occupant load for the area, then the exit capacity for the area is adequate.

E. Given a scenario that one exit may be incapacitated, if the remaining number of exits can provide egress capacity where neither of the remaining exits requires 50 % or greater of the occupants load for successful egress than the number of exits for the floor is deemed adequate, this requirement has been satisfied as detailed previously in the Egress Floor Plan in Figure 3.

F. Per section 7.3.3.3 of LSC the required capacity of a corridor shall be the occupant load that utilizes the corridor for exits to which the corridor connects, but the corridor capacity shall be not less than the required capacity to which the corridor leads [Ref1] see Table 5 for Corridor Load Capacities that show this requirement has been satisfied in conjunction with the floor plan details previously illustrated in the Egress Floor Plan in Figure 3

G. Per LSC Sec 7.4.1.2 (1) A total of three exits are required for the first floor and 1 exit from each respective balcony is required this requirement have been met as seen in the table above. Since there are a total of 15 means of egress that are accessible by a direct flow path for the 970 total occupants the building exit capacity requirement of 3 means of egress specified for 1000 of people in LSC section 7.4.1.2 (1) has been satisfied by building X [Ref:1].

NOTES ON STAIRS:

1) Stairs on the east side of the building provide egress to occupant load of 67 and the occupants 67s in the immediate area as previously illustrated in the Egress Floor Plan in Figure 3, horizontal exits are the primary exit discharge from the facility.

2) The two stairways to Balcony A and B can serve as areas of refuge since the all have 2 hour fire walls enclosing the vertical enclosure and meet the requirements of LSC section 7.2.12.2.3* Where the exit providing egress from an area of refuge to a public way that is in accordance with 7.2.12.2.2, and have stairs with a clear width of 66 inches which exceeds the requirement of stairs, the clear width of landings and stair flights, measured between handrails and at all points below handrail height, shall be not less than 48 in. (1220 mm), unless otherwise permitted by the following:

(1) The minimum 48 in. (1220 mm) clear width shall not be required where the area of refuge is separated from the remainder of the story by a horizontal exit meeting the requirements of 7.2.4. (See also 7.2.12.3.4.) (2) Existing stairs and landings that provide a clear width of not less than 37 in. (940 mm), measured at and below handrail height, shall be permitted [Ref:1].

TABLE 6 Stair Egress Capacity

STAIR LOCATION	CLEAR WIDTH (INCHES)	STAIRWAY WIDTH PER PERSON LSC TABLE 7.3.3.1	exit capacity	Maximum Required Capacity	EGRESS ALLOWANCE CAPACITY C = $146.7+(W_N-44)/0.218$	
EAST STAIRS	66	0.3	220	67	247.61	compliant
STAIRS FROM BALCONY A (enclosure)	66	0.3	220	10	247.61	compliant
STAIRS FROM BALCONY B (enclosure)	66	0.3	220	10	247.61	compliant

EGRESS COMPONENTS EVALUATED FOR EGRESS ALLOWANCE CAPACITY C = 146.7+(W_N-44)/0.218 IN TABLE 6:

FOR EAST STAIRS- Combined Occupant load for rooms A (1/2 x 56 =28 occupants) + B (25 occupants) + C (25/2= 14 occupants) = 67 occupants (see previously illustrated in the Egress Floor Plan in Figure 3) will use these stairs as an exit discharge to public way.

FOR STAIRS FROM BALCONY A (enclosure)-stairs serve as access from Balcony A not as an exit discharge to public way

Table 7 Exit Discharge (To Public Way) Doors on First Floor

Exit Discharge(ED) Door Exterior Door Number	Clear Width(inches)	Door size(inches)	Level Exit Component (LSC Table 7.3.3.1)	Calculated Egress Capacity of Exit (people)	See Figure 3 Maximum Required Capacity(people)	Spaces That Use Horizontal Exit (compliant if egress capacity is greater than occupant load reqd to use the subject path of egress)
EA ID C-1 access door from balcony A, area 3.02, and area 3.08	40	44	0.2	200	28	compliant
EA ID C-2 access door from balcony B, area 3.01, and area 3.07	40	44	0.2	200	27	compliant
ED1 EXT DOOR 1 (2x36)	72	40	0.2	360	105	compliant
ED2 EXT DOOR 2(single door)	40	44	0.2	200	9	compliant
ED3 EXT DOOR 3 (single door)	40	44	0.2	200	14	compliant
ED4 EXT DOOR 4 (2 X34)	68	40	0.2	340	31	compliant

Exit Discharge(ED) Door Exterior Door Number	Clear Width(inches)	Door size(inches)	Level Exit Component (LSC Table 7.3.3.1)	Calculated Egress Capacity of Exit (people)	See Figure 3 Maximum Required Capacity(people)	Spaces That Use Horizontal Exit (compliant if egress capacity is greater than occupant load reqd to use the subject path of egress)
ED6 EXT DOOR 6 (2 X 36)	72	44	0.2	360	120	compliant
ED8 EXT DOOR 8 (2 X 38)	76	44	0.2	380	76	compliant
ED9 EXT DOOR 9 (2 X 36)	72	44	0.2	380	189	compliant
ED9 EXT DOOR 10 (2 X 36)	72	44	0.2	360	43	compliant
ED11 EXT DOOR 11 (single door)	40	44	0.2	360	67	compliant
ED12 EXT DOOR 12(single door)	40	44	0.2	200	36	compliant
ED13 EXT DOOR 13(single door)	40	44	0.2	200	24	compliant
ED14 EXT DOOR 14(single door)	40	44	0.2	200	24	compliant
ED15 EXT DOOR 15 (2 X 36)	72	44	0.2	200	25	compliant
ED16 EXT DOOR 16 (2 X 36)	72	44	0.2	360	14	compliant

BALCONY B (enclosure)- stairs serve as access from Balcony B not as an exit discharge to public way

Table 7 Exit Discharge (To Public Way) Doors on First Floor

EA ID C-1 access door from balcony A has the Max number of 28 occupants (highlighted in yellow in Table 7 above) that access EA ID C-1 from Balcony A (10) plus1/ 2 occupants from an area 3.02 and area 3.08.

EA ID C-2 access door from balcony B has the Max number of 27 occupants (highlighted in yellow in Table 7 above) that access EA ID C-1 from Balcony B (10) plus 1/ 2 occupants from an area 3.01 and area 3.07

ED9 EXT DOOR 9 (2 X 36) shaded in grey has the highest value from occupant loads.

Max required capacity from second floor balcony is 10 people per balcony and the max egress capacity per balcony is 220; thus the total required balcony capacity is 20 and the max combined egress capacity per balcony is 440.

The maximum required capacity for the first floor is 950 + 20 occupants from the two balconies the total calculated egress capacity for the second floor from the 15 exit discharges is 4420.

Table 8 Corridor Load Capacities

Narrowest ACCESS CORRIDOR DESIGNATION	**Clear Width(inches)**	**Level Exit Component (LSC Table 7.3.3.1)**	**Calculated Egress Capacity of Exit (people)**	**See Figure 3 for Thin Lined Triangles with Maximum Required Capacity(people)**	**Internal access doors that provide corridor load**
Corridor 0.10 (section of corridor on the west side of corridor 0.09)	40	0.2	200	(8+8+9+4)/ (2 for two exits from corridor) = 29 total occupants; where 14 occupant exit from west end and 15 exit east exit access of the corridor.	ID1,ID2, ID3, and coffee shop
				29 Occupants	

29 Occupants is the highest number that will access the corridor as an exit. Since the calculated egress capacity is 200/ 2 required exits the corridor compliant with LSC 7.3.3.3.

Table 9 Estimated Evacuation Time

Exit Discharge(ED) Door Exterior Door Number	**Clear Width(inches)**	**Door size(inches)**	Boundary Layer (From NFPA HB Table 4.2.4)	We Effective Width inches	We Effective Width FT	Max Specific Flow Rate for Doors /corridors[Table4.2.8]	Max Flow (persons/min) for corridors & doors
EA ID C-1 access door from balcony A, area 3.02, and area 3.08	40	44	12	28	2.33	24	56
EA ID C-2 access door from balcony B, area 3.01, and area 3.07	40	44	12	28	2.33	24	56
ED1 EXT DOOR 1 (2x36)	72	40	16	56	4.66	24	112
ED2 EXT DOOR 2(single door)	40	44	12	28	2.33	24	56
ED3 EXT DOOR 3 (single door)	40	44	12	28	2.33	24	56
ED4 EXT DOOR 4 (2 X34)	68	40	12	56	4.66	24	112
ED6 EXT DOOR 6 (2 X 36)	72	44	12	60	5	24	120
ED8 EXT DOOR 8 (2 X 38)	76	44	18	58	4.83	24	116
ED9 EXT DOOR 9 (2 X 36)	72	44	12	60	5	24	120
ED9 EXT DOOR 10 (2 X 36)	72	44	12	60	5	24	120
ED11 EXT DOOR 11 (single door)	40	44	12	28	2.33	24	56
ED12 EXT DOOR 12(single door)	40	44	12	28	2.33	24	56

Exit Discharge(ED) Door Exterior Door Number	**Clear Width(inches)**	**Door size(inches)**	Boundary Layer (From NFPA HB Table 4.2.4)	We Effective Width inches	We Effective Width FT	Max Specific Flow Rate for Doors /corridors[Table4.2.8]	Max Flow (persons/min) for corridors & doors
ED13 EXT DOOR 13(single door)	40	44	12	28	2.33	24	56
ED14 EXT DOOR 14(single door)	40	44	12	28	2.33	24	56
ED15 EXT DOOR 15 (2 X 36)	72	44	12	60	5	24	120
ED16 EXT DOOR 16 (2 X 36)	72	44	12	60	5	24	120
ED17 EXT DOOR 17(single door)	40	44	12	28	2.33	24	56

Most restrictive components are doors leading to stairs in addition to the single doors leading from corridors (all of which have been shaded grey in Table 9). In general, these are the areas where it could be assumed queuing would occur. However, assuming occupants are distributed normally as depicted previously in the Egress Floor Plan in Figure 3, since there are normally only 10 occupants in each respective balcony and the first floor corridor's occupant loads are well below the maximum capacity flow rates, no density build up should occur in the event of a fire.

Corridor 0.10 (section of corridor on the west side of corridor 0.09)	40		12	28	0.194	24	4.66

Exit Access corridor at narrowest point

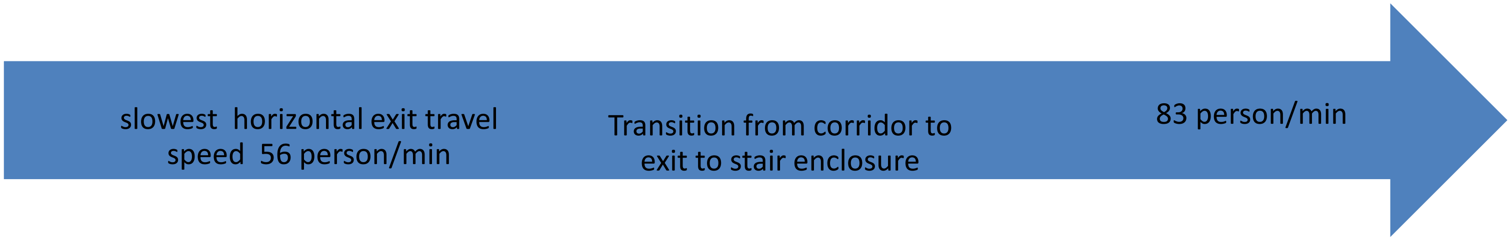

TABLE 10 Stairs Estimated Evacuation Time

New Construction Stair Risers and Treads 7 X 11	Clear Width(inches)	Boundary Layer (From NFPA HB Table 4.2.4)	We Effective Width inches	We Effective Width FT	Max Specific Flow Rate for Doors /corridors[Table4.2.8]	Max Flow (persons/min) for corridors & doors	Rounded down to nearest whole #
EAST STAIRS	66	12	54	4.5	18.5	83.25	83
STAIRS FROM BALCONY A (enclosure)	66	12	54	4.5	18.5	83.25	83
STAIRS FROM BALCONY B (enclosure)	66	12	54	4.5	18.5	83.25	83

corridor	Stair Exit Enclosure	Stairway exit to discharge
56 person/min →	83 person min →	120 people/min from corridor and through corridor exit door ED6 EXT DOOR 6

If a fire anomaly occurred no queuing would occur in the stairs or the corridors that lead from them since the stairs are to a balcony that has a maximum of 10 occupants.

Egress Time:

Note: The restrictive components are the 7 single door exit discharge doors (shaded in grey in Table 9) which have an exit capacity of 56 persons/min, which are the last exit element in the associated egress path that the main body of occupants will egress through.

Speed of movement down stairs = S=k-(akD)

Where s= Speed along the line of travel,

D= Density (person/unit area)

K=constant from Table 4.2.5, where Table 4.2.5 of NFPA HB K const= 275

a= 2.86 when calculating speed in ft./ min

Assumptions:

1. It was assumed that the due to the minimal occupant load of 10 occupants per stairway, the two stairways which had single doors and an egress capacity of 56 people/minute were not evaluated since egress through the 7 horizontal exits (single door exit discharge) with clear width of 40 inches was considered to be the most restrictive egress component of the design. Therefore, the 7 horizontal exits were evaluated in lieu of stairs, thus the total building population of 970 occupants that would have to egress through the subject 7 exits at any given time was target sample for evaluation however it was assumed that there would be minimal impact to reduction in egress time since the 7 exits egress capacities are 56 person/ min.

2. Horizontal Travel Distances (T1-T7) were measured from most remote point in room to one of the 7 exit discharge doors, which has the calculated minimal capacity of 56 people/minute, have been depicted below and used to calculate total travel distance to these exits.

Stairs were not evaluated as restrictive component, thus no conversion factor required.

Travel distance rounded up to nearest foot.

TABLE 11 Totals Possible Horizontal Travel Time

NFPA HB figure 4.2.7 assuming max specific flow is 0.175 person/ sq. ft.		
s=275-(2.86 x 275 x .175) =137.36	137.36	ft./min
T1 Horizontal Travel from Remote Point into ED DOOR E2	55	ft./min
T2 Horizontal Travel from Remote Point into ED DOOR3	36	ft./min
T3 Horizontal Travel from Remote Point into ED DOOR 11	106	ft./min
T4 Horizontal Travel from Remote Point into ED DOOR12	110	ft./min
T5 Horizontal Travel from Remote Point into ED DOOR 13	76	ft./min
T6 Horizontal Travel from Remote Point in to ED DOOR 14	76	ft./min
T7 Horizontal Travel from Remote Point into ED DOOR 17	105	ft./min
Total Sum horizontal travel distance from most remote point in room to one of the 7 exit discharge door	564	ft./min
Total possible horizontal travel time from most remote point to possible egress exits with the most limited egress capacity (see 7 exit doors in table 6 shaded in grey). Note, Per NFPA HB if population density exceeds 0.35 person/ft. 2 no movement can occur. Total Possible Horizontal travel time = Sum of horizontal distance/ S(rate) =	4.10	min

TABLE 12 Estimated Evacuation Time for Building

Building X Population that will use the 7 exist =ED 2(9) + ED 3(14) +ED 11(67) +ED 12(36) +ED 13(24) +ED 14(24) +ED 17(26)	970	people
discharge rate limited by 2 (40 ") clear width single doors from stairwell of building x = total of 2 x 56= 112	112	per/min
Time to exit building X = total persons/rate =	8.70	min
Total Sum horizontal travel (total horizontal distance/rate) =564/112	5.03	min
Total minimal evacuation time by 970 occupants through 7 exits with limited capacity.	14.15	min

4.4 Occupant Load / Egress Capacity / Number and Arrangement of Exits

Building X, Egress Analysis

The two fundamental concepts or overriding principles of egress that were evaluated and highlighted in the results of the egress analysis of building x were as follows:

1. Exit capacity has to exceed occupant load
2. Available safe egress time has to exceed required safe egress time: ASET>RSET

Where ASET is the available safe egress time before the fire area is exposed to a tenability parameter that can incapacitate the occupants.
Where RSET is the required safe egress time it takes the occupants to egress the fire area.

Exit Access, Exits, and Exit Discharge:
Only the stairs on the east side of the building serve as an exit discharge. These stairs will provide egress for 67 occupants but has an allowable egress capacity of 220 that can be increased to an allowable egress capacity of 247 occupants. These stairs are in compliance with LSC section 7.2.2.2.1.2(B) where stairs serving occupant loads exceeding that permitted by (A), the minimum width clear of all obstructions except projections not more than 4 ½ inches (114 mm) at or below the handrail height on each side, shall be in accordance with Table 7.2.2.2.1.2 (B) New Stair Width. Thus the stairs for Building X have been constructed with a clear width of 66 inches wide which exceeds the 36-inch width requirement specified in LCS Table 7.2.2.2.1.2 (B) which requires cumulative occupant load of less than 2000 person's stairs should be 44 inches. In addition, the risers of the stairs are no higher than 7 inches as required per LCS Table 7.2.2.2.1.1 (A) [Ref:1].

However, there are 15 horizontal exit discharges highlighted in yellow on the Egress Floor Plan in Figure 3 shown previously on page 14. Given the calculated occupancy building load of 970 occupants previously shown in Table 5 on page 16 because the occupant load is greater than 50 but not more than 1000, three means of egress are required for this one story building in addition to one exit per balcony for the 10 respective occupant to have egress access in accordance with the requirements in the LSC section 7.4.1.2 which states the number of means of egress from any story or portion thereof, other than for existing buildings as permitted in Chapters 11 through 43, shall be as follows:
(1) Occupant load more than 500 but not more than 1000—not less than 3
(2) Occupant load more than 1000 — not less than 4 [Ref: 1].

Building X provides at least one exit access for rooms with 16 occupants or less, two exits for all rooms that have 17 or more occupants, three exits for the office area that has 89 occupants, and has a total of 15 exits that area accessible by a direct flow path the exit capacity requirement specified for 1000 people in LSC section 7.4.1.2 (1) has been satisfied and therefore is compliant with the required number of exits.

All interior door(s) that serve as either as single or multiple exit access doors in Building X meet the capacity requirements see Table 4 in Appendix B of 7.3.4.2 Where a single exit access leads to an exit, its capacity in terms of width shall be not less than the required capacity of the exit to which it leads 7.3.4.3 Where more than one exit access leads to an exit, each shall have a width adequate for the number of persons it accommodates.

Effective width measurements of the means of egress of the narrowest components were used in the calculation of egress capacities in Appendix B. To determine compliance, the lowest capacity for an egress component must be greater than the calculated occupant load for that story. As Appendix B shows, all components of egress (corridors, stairs, and exits) capacities are greater than the maximum required capacity predicated by the occupant load.

All office partitions and all other movable furniture have exit access widths in excess of 36 inches of egress as shown previously in the Egress Floor Plan in Figure 3 and listed previously in the Egress Analysis on page 16 and meet the criteria specified in LSC section 7.3.4.1. Where LSC section 7.3.4.1 states the width of any means of egress, unless otherwise provided in LSC section 7.3.4.1.1 through LSC section 7.3.4.1.3, shall be as follows:

(1) Not less than that required for a given egress component in this chapter or Chapters 11 through 43 (2) Not less than 36 in. (915 mm) where another part of this chapter and Chapters 11 through 43 do not specify a minimum width [Ref:1].

There are a total of 15 exit discharges all of which can be accessed by the physically impaired. Sixteen exit discharges are on the first floor and one is a set of stairs on the east side of the building with a handicap exit ramp. This ramp is a TYPE III B permanent fixed construction and has a clear width of 44 inches without perforations with an attached landing and hand rails that comply with LSC sections 7.2.5.3.2 thru 7.2.5.4.1 the ramps construction satisfies the requirements for ramps set forth in the LSC section 7.2.5.3. LSC section 7.2.5.3.1 state ramp construction shall be as follows:

(1) All ramps serving as required means of egress shall be of permanent fixed construction.

(2) Each ramp in buildings required by this *Code* to be of Type I or Type III B construction shall be any combination of noncombustible or limited-combustible material or fire-retardant-treated wood.

(3) Ramps constructed with fire-retardant-treated wood shall be not more than 30 in. (760 mm) high, shall have an area of not more than 3000 ft2 (277 m2), and shall not occupy more than 50 percent of the room area.

(4) The ramp floor and landings shall be solid and without perforations.

7.2.5.3.2 Landings. Ramp landings shall be as follows:

(1) Ramps shall have landings located at the top, at the bottom, and at door leaves opening onto the ramp.

(2) The slope of the landing shall be not steeper than 1 in 48.

(3) Every landing shall have a width not less than the width of the ramp.

(5) Every landing, except as otherwise provided in 7.2.5.3.2 Shall be not less than 60 in. (1525 mm) long in the direction of travel, unless the landing is an approved existing landing.

(6) Where the ramp is not part of an accessible route, the ramp landings shall not be required to exceed 48 in. (1220 mm) in the direction of travel, provided that the ramp has a straight run.

(7) Any changes in travel direction shall be made only at landings, unless the ramp is an existing ramp. Ramps and intermediate landings shall continue with no decrease in width along the direction of egress travel.

7.2.5.3.3 Drop-Offs. Ramps and landings with drop-offs shall have curbs, walls, railings, or projecting surfaces that prevent people from traveling off the edge of the ramp. Curbs or barriers

(1) shall be not less than 4 in. (100 mm) in height [Ref: 1].

Building X has 15 means of egress that are accessible to by the physically impaired. Exit discharge door ED 5 and ED 7 in mechanical rooms 5.00 and 3.00 were not counted as part of the 15 means of egress for the physically impaired since there are no defined flow paths in those rooms and obstacles in the room may restrict flow. All exits, exit accesses, and exit discharges are all on the first floor except for the two exit accesses and stairways that lead from the two balconies. All corridors are centrally located and have and accessible by physically impaired individuals. Thus building X satisfies all the requirements in LSC section 7.5.4.1*. LSC section LSC section 7.5.4.1* states areas accessible to people with severe mobility impairment, other than in existing buildings, shall have not less than two accessible means of egress, unless otherwise provided in LSC section 7.5.4.1.2 through LSC section 7.5.4.1.4 [Ref: 1].

The large corridor runs west to east, the larger corridor that runs south and north, along with the two stairways (which also have fire doors and provided with emergency lighting) all of which are sprinkled and protected by two hour fire walls and are located in the rear of the building in accordance with LSC section 7.5.4.1.1 which states access within the allowable travel distance shall be provided to not less than one accessible area of refuge or one accessible exit providing an accessible route to an exit discharge [Ref:1].

Given Building X's designed separation and orientation of all exits, exit access, exit discharge Building X (previously illustrated in the Egress Floor Plan in Figure 3) satisfies the remoteness requirements room specified in LSC section: 7.5.1.3 which states remoteness shall be provided in accordance with LSC 7.5.1.3.1 through LSC section 7.5.1.3.7. 7.5.1.3.1 Where more than one exit, exit access, or exit discharge is required from a building or portion thereof, such exits, exit accesses, or exit discharges shall be remotely located from each other and be arranged to minimize the possibility that more than one has the potential to be blocked by any one fire or other emergency condition. 7.5.1.3.2* Where two exits, exit accesses, or exit discharges are required, they shall be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area to be served, measured in a straight line between the nearest edge of the exits, exit accesses, or exit discharges, unless otherwise provided in 7.5.1.3.3 through 7. 5.1.3.5.

Since Building X is sprinkled it would be allowed to meet the following provision if it did not already meet aforementioned provision LSC section 7.5.1.3.2*. 7.5.1.3.3 In buildings protected throughout by an approved, supervised automatic sprinkler system in accordance with Section 9.7, the minimum separation distance between two exits, exit accesses, or exit discharges, measured in accordance with 7.5.1.3.2, shall be not less than one-third the length of the maximum overall diagonal dimension of the building or area to be served [Ref1].

Building X exit access doors from offices, rooms, stairways, and shops do not extend further than 7 inches into a passage or corridor and is in compliance with LCS section 7.2.1.4.3. LCS section 7.2.1.4.3 states all exit access doors shall not project no further than 7 inches into the passage way or corridor in accordance with LCS section 7.2.1.4.3 Door Leaf Encroachment. 7.2.1.4.3.1* During its swing, any door leaf in a means of egress shall leave not less than one-half of the required width of an aisle, a corridor, a passageway, or a landing unobstructed and shall project not more than 7 in. (180 mm) into the required width of an aisle, a corridor, a passageway, or a landing, when fully open, unless both of the following conditions are met:

(1) The door opening provides access to a stair in an existing building.
(2) The door opening meets the requirement that limits projection to not more than 7 in. (180 mm) into the required width of the stair landing when the door leaf is fully open [Ref:1]

<u>Corridor Capacity and Area of Refuge:</u>
Building X narrowest corridor, corridor 0.10 has 29 occupants as the highest number of occupants that will access the corridor as an exit. Since the required capacity is 200/2 = 100 and the actual calculated egress capacity is 200 (see Appendix B) Building X is compliant with LSC 7.3.3.3 the required capacity of a corridor shall be the occupant load that utilizes the corridor for exit access divided by the required numbers of exits to which the corridor connects.

Building X satisfies the following LSC sections as previously illustrated in the Egress Floor Plan in Figure 3:
LSC 7.5.1.1.2 Exit access corridors shall provide access to not less than two approved exits, unless otherwise provided in LSC 7.5.1.1.3 and LSC 7.5.1.1.4.

LSC 7.5.1.2 Corridors shall provide exit access without passing through any intervening rooms other than corridors, lobbies, and other spaces permitted to be open to the corridor, unless otherwise provided in LSC 7.5.1.2.1 and LSC 7.5.1.2.2 [Ref:1].
Area of Refuge, which have been labeled on the previously illustrated Egress Floor Plan in Figure 3, Building X although it has a supervised automatic sprinkler system, the areas of refuge is accessible from the space they serve and portions of an area of refuge and have access to a public way via an exit and satisfies the requirements for areas of refuge set forth in LSC 7.2.12.1.2 (1) and (2)

Portions of the designated areas of refuge are accessible from the space they serve by an accessible means of egress in accordance with 7.2.12.2.1.
7.2.12.2.2 Required portions of an area of refuge shall have access to a public way via an exit or an elevator without requiring return to the building spaces through which travel to the area of refuge occurred.

7.2.12.2.3* Where the exit providing egress from an area of refuge to a public way that is in accordance with 7.2.12.2.2 includes stairs, the clear width of landings and stair flights, measured between handrails and at all points below handrail height, shall be not less than 48 in. (1220 mm), unless otherwise permitted by the following:
(1) The minimum 48 in. (1220 mm) clear width shall not be required where the area of refuge is separated from the remainder of the story by a horizontal exit meeting the requirements of 7.2.4. *(See also 7.2.12.3.4.)*
(2) Existing stairs and landings that provide a clear width of not less than 37 in. (940 mm) measured at and below handrail height, shall be permitted [Ref1].

4.5 Travel Distance and Egress Time:
The three longest travel distances are188 ft., 156 ft., and 124 ft. respectively from the most remote rooms in Building X, which has an automatic supervised sprinkler system, to the exit discharge have been measured from the center of the room, around the corner, and terminating at the center of the door way (see previously illustrated Egress Floor Plan in Figure 3,) as depicted in accordance with LSC 7.6.1.

There are no high hazards in currently in Building X and due to facility restrictions no high hazards will be allowed in the future. Therefore, the requirements stated in LSC 7.6.6 regarding travel distance limitations in high hazard areas are not applicable.

As concluded the 970 occupants that would have to access the 7 single doors listed in Table 9 would have total possible horizontal travel time from most remote point to possible egress exits of 4.105999 minutes and evacuation of total building population has been calculated as 6.4 minutes as previously calculated in Tables 11 and 12 on page 27 and 28 respectively.

4.6 Interior Finishes
The Interior wall and ceiling finish in exit enclosures in Building X have been constructed as class B in compliance with LSC 7.1.4.

4.7 Emergency Lighting
Emergency lighting has been provided in the designated areas of refuge and installed in accordance with LSC 7.9.1.1 and meet the performance criteria specified in LSC section 7.9.2 and will undergo the periodic testing specified in 7.9.3 [Ref1].

4.8 Marking of Means of Egress
In accordance with LSC section 7.10.1.2.2. approved signs that are readily visible from any direction of exit access in Building X have been provided for exits other than main exterior exit doors that obviously and clearly are identifiable as an exit. In addition, horizontal components of egress have been marked with approved signage or directional exits where the continuation of the path of egress is not obvious in accordance with LSC section 7.10.1.2.2. Exit sign designations have been marked with a circle where two opposites sides of the circle have been shaded (see previously illustrated Egress Floor Plan in Figure 3,).

4.9 Prescriptive Analysis Summary
The allowable gross area for Building X, which is a Type III B construction, was increased from the required 23,000 square feet to 75,674 square feet since Building X is fully protected by an automatic sprinkler system. Building X is a one-story building with two internal balconies with 10 occupants per balcony, which is made of non-combustible materials that also has a partial basement with concrete walls (is normally unoccupied). There are two sets of interior stairs that go up to the balcony, the partial basement is accessed through an external door down at the basement location (building is orientated on a hill).
This building also falls under the definition of mixed occupancy per LSC sec 6.1.14.2.2 where the

two occupancies must be separated 2-hour fire resistant rated construction However, since Building X is fully protected by an automatic sprinkler system the 2-hour rating requirement has been relaxed to a 1-hour rating.

There are 15 horizontal exit discharges that serve as exits which are protected by either a 1 or 2-hour fire barriers in the form of 1 or 2-hour fire walls which serve as the primary exits for a calculated occupancy building load of 970 occupants that was provided in Table 5. Building X provides at least one exit access for rooms with 16 occupants or less. There are two exits for all rooms that have 17 or more occupants. There are three exits for the office area that has 89 occupants which has a total of 15 exits that are accessible by a direct flow path the exit capacity requirement specified for 1000 people in LSC section 7.4.1.2 (1) has been satisfied and therefore is compliant with the required number of exits.
Building X has 15 means of egress that are accessible by the physically impaired. Exit discharge door ED 5 and ED 7 in mechanical rooms 5.00 and 3.00 were not counted as part of the 15 means of egress for the physically impaired since there are no defined flow paths in those rooms and obstacles in the room may restrict flow. All exits, exit accesses, and exit discharges are all on the first floor except for the two exit accesses and stairways that lead from the two balconies. All corridors are centrally located and accessible by physically impaired individuals.

Building X narrowest corridor, corridor 0.10 has 29 occupants as the highest number of occupants that will access the corridor as an exit. Since the required capacity is 200/2 = 100 and the actual calculated egress capacity is 200 (see Appendix B), Building X is compliant with LSC 7.3.3.3.

Areas of Refuge have a supervised automatic sprinkler system. The areas of refuge are accessible from the space they serve and portions of an area of refuge and have access to a public way via an exit and satisfies the requirements for areas of refuge set forth in LSC 7.2.12.1.2 (1) and (2).

The three longest travel distances are188 ft., 156 ft., and 124 ft. respectively from the most remote rooms in Building X, which has an automatic supervised sprinkler system, to the exit discharge have been measured from the center of the room, around the corner, and terminating at the center of the door way as depicted in accordance with LSC 7.6. As concluded, the 970 occupants that would have to access the 7 single doors listed in Table 9 would have total possible horizontal travel time from most remote point to possible egress exits of 4.10 minutes and evacuation of total building population has been calculated as 6.4 minutes as previously calculated in Tables 11 and 12 on page 27 and 28 respectively. The Interior wall and ceiling finish in exit enclosures in Building X have been constructed as class B in compliance with LSC 7.1.4.

Emergency lighting has been provided in the designated areas of refuge and installed in accordance with LSC 7.9.1.1 and meet the performance criteria specified in LSC section 7.9.2 and will undergo the periodic testing specified in 7.9.3. Approved signs that are readily visible from any direction of exit access in Building X have been provided for exit and horizontal components of egress have been marked with approved signage or directional exits.

5.0 Fire Protection Systems

<u>General System Configuration:</u>

The water for the suppression system is supplied from a fire water storage tank located approximately 100 yards from Building X. A heated enclosed pump house constructed and maintained in accordance with NFPA 20, houses one electric jockey pump and one back up diesel pump. Both pumps controllers are set for both respective pumps to start in automatic mode. The jockey pump maintains system pressure of the underground pipe from the pump house to the standpipe in the mechanical room of building X between 125 psi and 129 psi. When the pressure falls below 117 psi the diesel pump will kick on until it is shut off manually or until pump failure occurs as prescribed in NFPA 20. The standpipe in the mechanical room supplies two loops of pipe that can be put on line interchangeably, each respective line has a check valve and water flow meter attached to it. In addition, the isolation valves have a supervisory signal device that sends an alarm to the control panel. Actuation of the flow meter and or a pull alarm will alert personal to evacuate the building and send a signal to the panel located in the main corridor which is transmitted to a secondary responder who contacts Burke County fire department and the control room simultaneously. The

system defined above satisfy the following LSC requirements: 7.14.4.1 The building shall be protected throughout by an approved, supervised automatic sprinkler system in accordance
with 9.7.1.1(1), except as otherwise specified in 7.14.4.2. and 7.14.4.1.1 a sprinkler control valve and a water flow device shall be provided for each floor. 7.14.4.1.2 The sprinkler control valves and water flow devices required by 7.14.4.1.1 shall be monitored by the building fire alarm system [Ref: 1].

Detection:
All smoke detectors and flow alarms feed into a Siemen's fire alarm panel located in the main corridor. The panel in turn sends a signal through a phone line to a monitoring company which notifies Burke County fire department and the control room on site.

Alarm System Type, Model, and Building Location:
Below in Table 13 the part numbers, description, and manufacturer of the components that make up the alarm system are listed.

Table 13 Alarm System Descriptions and Part Numbers

Part Number	Description	Manufacturer
NFS-3030	Fire Alarm Control Panel	Notifier
DVC	Digital Voice Command	Notifier
DAA Seriies	Digital Audio Amplifiers	Notifier
UDACT	Universal Digital Alarm Communicator/Transmitter	Notifier
LCD-160	Liquid Crystal Display	Notifier
FCPS-24S8	Field Charger/Power Supply	Notifier

The building has one Notifier Addressable Fire Alarm Control Panel NFS2-3030 located at 66" AFF to top of cabinet and is located in the main corridor.

5.1 Fire Alarm System Operating Characteristics:
The NFS2-3030 Intelligent Alarm Panel listed to UL standard 864, 9th edition has one to ten Signaling Line Circuits (SLCs) and supports up to 3180 intelligent addressable devices. It also has a 640character Liquid Crystal Display (LCD) that provides vital life safety information to operations concerning a fire situation, fire progression, and evacuation details. The Universal Digital Alarm Communicator Transmitter (UDACT) is capable of reporting up to 2040 points either in the form of points or zones. It is capable of transmitting the status of software zones (Alarm and Trouble), System Trouble, Panel Off Normal, Supervisor, Bell Trouble, Low battery, and AC Fall. The UDACT is capable of transmitting all of the zones and points status associated with each panel. The primary function of the UDAC is to obtain and transmit the system status received by all connected alarm panels to a to UL Listed Central Station receivers.

Detection:
The Notifier alarm system supports the following automatic alarms from various input devices such as smoke detectors, 2 potter water flow alarms located on the 2 risers, heat detectors, gas filled sprinklers, burglar alarm contacts, and manual pull stations as well.

Notification:
The alarm system supports two separate digital phone lines that send a signal to an independent monitoring station which notifies the Burke County fire department and the control room in the event of a possible fire at the facility.
There are internal fire alarms located inside the building that will actuate if either of three events occurs:
1. A smoke detector sends a signal to the alarm where it has detected a fire
2. A heat detector sends a signal to the alarm where it has detected smoke from a fire.
3. A sprinkler actuates after as a result of the heat release rate reaching a temperature resulting in that sprinkler actuating ultimately resulting in one or both of the two flow meters on the riser actuation (which will specifically result in a flow bell external to the building actuating)

The alarm system also has a voice command system which allows direct voice commands to be given to building occupants over the PA system.

Suppression/Sprinklers:
Sprinklers with glass bulbs will actuate when the glass bulbs of the sprinklers are exposed to heat in excess of their designed temperature ranges and in turn a signal will be sent to the alarm system which would result in the system actuation a fire alarm in the building and sending a fire alarm signal to the independent monitoring station which will notify the Burke County fire department and the control room of a possible fire event.

Types of Signals Supported Alarm System:
The following three types of signals are supported by this alarm system:
Alarm Signal- A warning fire signal that requires immediate action in response to a possible fire event. For example, alarms given from smoke or heat detectors, burglar contacts, sprinkler actuation or water flow alarm signals.
Supervisory notification- alarms will be sent to the alarm system for low water level alarms, after the tamper switches have been actuated when the suction and discharge isolation valves on the supply line from the diesel pump and the two isolation valves on each riser have been manipulated.
Trouble Alarms- are alarms that give indication that there is a problem with the system that may prohibit it from functioning properly when called upon. For example, these alarms may be fault alarms where the test signal sent from the alarm panel on site to the receiver at the independent monitoring station does not return correctly because the codes on the two units do not match and the units can't confirm communication when the daily test signal is sent from the alarm panel. Also adequate power supply or back up power supply has been disengaged may result in a trouble alarm.

The system operates in System Normal mode when no alarms or troubles exist and will display a "System Normal" on the screen of the alarm panel.

The control panel performs the following functions at regular intervals:

- Polls all SLC devices and Panel Circuits to check for valid replies, alarms, troubles, circuit integrity, and supervisory signals, etc.
- Checks power supply troubles and batteries
- Refreshes the panel display and updates time
- Scans for any panel screen, keypad, and Control Key entries
- Performs a detector automatic test operation
- Tests system memory
- Monitors for microcontroller failure

No action is required of the operator when the panel is operating in Normal mode.

Detector Types and Location:
The building has six Notifier DNR/FSP-851R/DST5 Addressable Smoke Detector (Return) located in the duct work. The building has five Notifier DNR/FSP-851R/DST5 Addressable Smoke Detector (Supply) located in the duct work. These detectors are photoelectric detectors that draw air flow from left to right through a series of tubes in accordance with NFPA 98. This type of low –flow detector provides low flow technology that can detect smoke at air speed velocities of 100 feet per minute (0.5 sec) or greater, while continuing the same reliable performance to 40,000 feet per minute. The intelligent low –flow duct detectors samples the air currents passing through a duct and gives dependedable performance for shutdown of fans, blowers, and air conditioning systems. This action prevents the spread of toxic smoke through the protected area.

In addition, per NFPA 90A (6.4.3.1), duct smoke detectors were installed and arranged to shut down their respective air handling unit and close their respective fire/smoke dampers. Smoke detectors for the control of smoke spread are restorable, spot type photoelectric duct type smoke detectors with sampling tubes. The smoke detector for door release is a restorable, spot type photoelectric smoke detector.
Open area beam detectors were installed in the atrium to operate the atrium smoke management system that is required by the IBC (404.5); and a smoke detector was installed to automatically release power to a two pairs of normally open smoke barrier doors serving the atrium per NFPA 101 (8.5.4.4).

The building has 27 Notifier FSP-851 and FSP-851/B710LP Addressable Photoelectric Smoke Detectors that are installed throughout the building (see the previously illustrated Egress Floor Plan in Figure 3, for the locations that are designated by the applicable symbol for this type of detector). These smoke detectors have Point ID capability which allows each detector's address to be set with decade address switches which provide exact locations. These detectors use dual thermistor s sensing circuit to add 135°F (57°C) fixed temperature thermal sensitivity on the (FSP-851). These are addressable devices with two wire SLC-connection. Operating temperature ranges: FSP-851 Series, FSP-851T: 0°C to 49°C (32°F TO 120°F); FSP-851T: 0°C to 38°C (32°F TO 120°F). Detectors have been installed by the NFPA 72-2010; 17.6.3.1 recommended spacing. In low air flow applications with smooth ceilings, space detectors 30 feet (9.144 m) for ceiling heights 10 feet (3.148 m) and higher. The humidity rating; relative humidity: 10%-93% non-condensing. The thermal Ratings: have a fixed temperature set point of 135°F (57°C). Detectors installed on the ceiling at the factory presetting of 135 °F in accordance with NFPA 72 2010 and Per the SFPE HB Table 4-1.1. The fire signature detected by this type of device is after visible smoke and products of combustion more than 0.1 microns. Once the fire plume hits the ceiling it will result in a ceiling jet to spread radially and enter the outer shell and into the inner shell then inside the detection chamber which ideally should be dark. Inside the inner chamber there is a radioactive source between two electrodes that produces and the radiation generates a flow of electricity in the circuit which is slowed down when smoke particles gather on the charged particles gather which slow them down and change the electrical flow which is read as detection.

A major issue is the blindness to smoldering smoke where you can have dense static smoke outside the detector but if there is no air flow to force smoke into the detector to bypass the entry resistance then the detector will not pick up the smoke; normally an air velocity of 6 inches /sec past the detector is required in order for the smoke to be forced into the outer shell.

The building has three Notifier FST-851/B710LP Addressable Heat Detectors mounted on the ceiling at the factory presetting of 135 °F and have been marked with their listed operating temperature in accordance with NFPA 72-210; section 17.6.2.2.2.1(see previously illustrated Egress Floor Plan in Figure 3, for the locations that are designated by the applicable symbol for this type of detector). These heat detectors have Point ID capability which allows each detector's address to be set with decade address switches which provide exact locations. These detectors use an innovative thermistor sensing circuit to produce 135°F/57°C fixed temperature (FST-851) and a rate of rise thermal detection (FST-851R) in a low profile package. The addressable devices with two wire SLC-connection. Operating temperature ranges: FST-851 Series, FST-851R:-20 °C to 38°C.; FST-851H:-20°C to 66°C. The UL approved spacing is 50ft center to center and FM approved for 25 X 25 Ft spacing with an RTI of <5 ft. $\cdot$S)$^{1/2}$.
The humidity rating; relative humidity: 10%-93% non-condensing. Thermal Ratings: Fixed Temperature Set point 135°F (57°C), rate of rise detection 15°F (8.3°C) per minute, high temperature heat 190°F (88°C). Altitude rating 10,000 FT. Heat detectors comply with NFPA 72-2010; section 17.6.2.3* Ambient Ceiling Temperature. Detectors having fixed-temperature or rate-compensated elements shall be selected and color coded in accordance with Table 17.6.2.1 for the maximum expected ambient ceiling temperature. The temperature rating of the detector shall be at least 20°F (11°C) above the maximum expected temperature at the ceiling. Per the SFPE HB Table 4-1.1 the fire signature detected by this type of device is after visible smoke and products of combustion more than 0.1 microns. Since this is a UL listed 521 detector it must actuate prior to a rated 160°F sprinkler or 2 minutes. The heat detectors are marked with their listed operating temperature in accordance with NFPA 72-2010; sec 17.6.2.2.2.1.

Detector Location and Spacing:
Duct smoke detectors were installed to obtain a representative sample of the airstream and per manufacturer's instructions. In order to achieve this detector were located away from duct bends where air flow may be turbulent. Smoke detectors were installed in accordance with NFPA 72-2010; sec 17.7.1.8 where unless specifically designed and listed for the expected conditions, smoke detectors shall not be installed if any of the following ambient conditions exist:
(1) Temperature below 32°F (0°C)
(2) Temperature above 100°F (38°C)
(3) Relative humidity above 93 percent
(4) Air velocity greater than 300 ft./min (1.5 m/sec).

Heat detectors are UL approved spacing is 50ft center to center and FM approved for 25 X 25 Ft spacing with an RTI of <5 ft. ·S)$^{1/2}$ which is compliant with FM3210; 3.2.1.8 standards. Per the floor plan the detectors are located in small rooms which are best suited for heat detector applications. Heat and smoke detector spacing general requirements are depicted in NFPA 72 (17.6.3 and 17.7.3, respectively). However, NFPA 72 (17.6.3.8 and 17.7.1, respectively) also permits spacing to meet the alternative design methods offered by Annex B. The location and spacing of the smoke detectors are in accordance with the following sections of NFPA 72-2010; 17.7.3.1.1. The location and spacing of smoke detectors shall be based upon the anticipated smoke flows due to the plume and ceiling jet produced by the anticipated fire, as well as any pre-existing ambient airflows that could exist in the protected compartment. 17.7.3.1.2 The design shall account for the contribution of the following factors in predicting detector response to the anticipated fires to which the system is intended to respond:
(1) Ceiling shape and surface
(2) Ceiling height
(3) Configuration of contents in the protected area
(4) Combustion characteristics and probable equivalence ratio of the anticipated fires involving the fuel loads within the protected area
(5) Compartment ventilation
(6) Ambient temperature, pressure, altitude, humidity, and atmosphere

17.7.3.1.3 If the intent is to protect against a specific hazard, the detector(s) shall be permitted to be installed closer to the hazard in a position where the detector can intercept the smoke.

Notification Appliance Type, Alarm Signals, and Location**:**
Audible Notification Appliances (NA) for Public Mode Audio Requirements per NFPA 72, 18.4.3 were selected (See Appendix C for NA cut sheets) and located such that the sound level of a 3 pulse temporal tone which is required per NFPA 72, 18.4.2.1 would be less than 75 dBA at 10 ft. Since the average ambient noise level per NFPA 72 Table A .18.4.3 for a business building is 55 dBA, 70 dBA audible appliances were selected which meets the 15 dBA above the average ambient noise level (which is 55 dBA for a business building) and last for a duration of 60 seconds as required per NFPA 72, 18.4.3.1. The candela strobes meet the requirements of NFPA 72-2010, sec 18.5 which states where in accordance with 18.5.2 the flash rate between 1-2 Hz through of the listed voltage range max pulse duration of 0.2 second, defined as interval between 10% of max signal. Maximum cycle of 40% lights used for fire alarms or complete evacuation shall be clear or white and shall not exceed 100cd effective intensity. Therefore, the building's audible notification appliances meet NFPA requirements.

All building occupants will be notified by visible and audible notification through the use of the following appliances located at their list locations which can be seen on the previously illustrated Egress Floor Plan in Figure 3:
4 Horn Strobe/75 CD, Wall Mount Red Wheelock HSR located 80"A.F.F. to the center lens.
57 Speaker Strobe/75 Multi-Candela Wheelock E50-24MCW-FR located 80"A.F.F.
75 Strobe, Selectable Candela Wall Mount Wheelock STR located 80"A.F.F.
8 Addressable Relay Module Notifier FRM-1 located as needed
1 Universal Digital Alarm Communicator/Transmitter Notifier UDACT located as needed.
2 Digital Audio Amplifiers Notifier DAA-5025 located 66" A.F.F. to top of cabinet.
1 Digital Voice Evacuation Control Panels Notifer DVC-EM located 66" A.F.F. to top of cabinet.

4 Field Charger Power Supply Amps Notifier FCPS-24S8 located 66” A.F.F. to top of cabinet.
2 Sprinkler Valve Tamper Switches by Others by Others by Others
2 Sprinkler Water Flow Switches by Others by Others by Others
4 Surge Suppressor,120 VAC DTK-120HW Mounts in Panel cabinet.

Any occupants external to the building that are in close proximity to the mechanical room will hear a water gong once water flow greater than 7 gpm occurs in the riser that supplies water to the building sprinklers. In addition, all rooms and hallways have strobes for visible notification of fires. The Notifier Emergency Command Center located in the basement provides manual voice override capability that will be provided to emergency response personnel via a microphone.

Wiring to signaling line circuits and notification appliance circuits are Class B. Pathway survivability and meets Level 2 per NFPA 72, 12.3 using two-hour CI cable.
This fire alarm and emergency voice alarm system will transmit both alarm and supervisory signals to ADS which is a UL listed central station service. ADS will immediately contact the Burke County Fire Department and the Control Room to initiate an emergency response to a possible fire. Alarm, Supervisory, and Trouble signals will show up on the Notifier Emergency Command Center and alarm panel and issue and audible alarm and an LCD alarm description at the panel in the main hall way, where that Supervisor or Trouble signal will in turn be transmitted by the UDACT to the central station, who will in turn contact building maintenance to confirm if they are aware of the signal.

5.2 Spacing Requirements of Notification Appliances
Speakers-strobes were spaced as required by their listing and NFPA 72, Table 18.5.4.3.1(a).
57 Speaker Strobe/75 Multi-Candela Wheelock E50-24MCW-FR located 80”A.F.F. candela appliances won’t exceed a 45’ x 45’ spacing; 55 Strobe, Selectable Candela Wall Mount Wheelock STR located 80”A.F.F. candela appliances won’t exceed a 30’ x 30 ’ spacing where in rooms with one light the candela is 34 and where there are two lights a candela of 15. All building candelas and strobes were locate at 80”A.F.F and thus comply with NFPA 72, 18.5.4.1 wall-mounted appliances shall be mounted such that the entire lens is not less than 80 in(2.03m)and not greater than 96 in (2.44 m) above the finished floor or at the mounting height specified using the performance based alternative of 18.5.4.5. NFPA 72, 18.5.4.4.5, 20-candela appliances were installed within 15 feet of the ends of every corridor. All lights used for fire alarm signaling only or to signal the intent of a complete evacuation shall be clear or normal white and shall not exceed 1000 cd.

5.3 Mass Notification Systems
Building X has a 1 Digital Voice Evacuation Control Panel Notifer DVC-EM located 66” A.F.F. to top of cabinet. This unit has the capability issuing non-fire mass notifications in the event of tornado or some other life threatening event. The DVC can be networked with ONYX Series panels via NOTI-Fire-Net with an NCA-2. The associated NCA-2 supports NOTI-Fire-Net applications. Multiple audio command centers support NOTI-Fire-Ne including distribution of one channel of standard level paging audio on NOTI-Fire-Net, which provide the following three standalone options:
-NFS2 3030 (NUP to NUP) digital and analog
- NFS2 3030 (NUP to NUP) digital and analog
- NFS2 640 (NUP to NUP) analog
- NFS2 640 with NCA-2(NUP to NUP to NUP) digital and analog
    - Push to talk
    - Isolation alarm bus, to be used for back up activation of alarm messages when normal digital communication is lost.

5.4 Secondary Power Supply
There are 4 circuits which powered by four field charger power supplies FCPS-24S6C/24SBC:120vac,60 Hz,3.2 A max that are rated at 8 amps (see cut sheet in Appendix C). Three are installed on the main floor and the fourth is located at the basement level. Each field charger power supplies supports one of the four circuits. Each one also ties into the addressable fire alarm control panel. This configuration provides redundant back up power supply. That way, should there be a problem between the fire alarm panel and the auxiliary power supplies, notification appliances can still be powered by their respective power supply.

All notification appliances, initiating, and signaling devices are powered from the main fire alarm control panel located in the main hall way on the first floor. The main power supply of the control panel must be able to power all internal system devices as well as several external devices continuously during non-fire alarm conditions and provide additional current during a fire alarm condition. The Alarm current draws in AMPS-24 during a non-fire alarm condition, with AC power applied; where the total current draw cannot exceed 4.5 A of filtered DVDC power or 3.5 A of filtered 1.0 A of supervised 24VDC.
The system contains capacity to activate all output circuits and relays and support fire alarms on less than 10 % of initiating devices circuits, subject to the requirements of the authority having jurisdiction (AHJ).
The control panel provides power for notification appliance circuits as referenced in the device compatibility document for 24DC notification appliances that are UL/ULC-listed for fire alarms systems.
A 55 HZ battery (which was D rated by the vendor by 25 %) supplies a surplus of 7.132 Amps which more than meets the battery capacity required to sustain the system for 24 hours in standby and 5 minutes in alarm mode by the Local Proprietary, and Central Stations as required per NFPA 72.
Emergency voice/alarm communications systems require 2 hours of operation in alarm condition. However, due to the sporadic nature of voice operation, NFPA 72 permits 15 minutes of operation at a maximum connected load equal to 2 hours of normal use. If the total exceeds 200 AH, an uninterruptible power supply must be the UL-listed for Fire-Protective Signaling.

Voltage drop calculations were conducted to assess the wire gauge size and amount of wire needed for the notification appliance circuits. Since NFPA 72, 10.14.1 requires the system be designed at 85% of the nameplate voltage, the voltage available to power the notification appliances starts at 20.4 volts. And given the minimum operating voltage of the appliances is 16 volts, then the maximum voltage drop permitted is 4.4 volts. Using14 AWG stranded wire, per NFPA 70 Table 8 of the, the wire resistance is 3.14 ohms/1000'. The maximum wire length will be dependent upon voltage drop, wire resistance and the current draw by each circuit.

5.5 Inspection, Testing, and Maintenance
In general, the requirements for inspection –testing-maintenance for the following listed alarm, detection, and mass notification appliances are located in NFPA 72 chapter 14. The standard for inspection is condensed in Table 14.3.1, testing is in table 14.4.5, and maintenance is in 14.5, but there is no table for maintenance which is primarily based manufacturer's recommendations.
Prior to building turnover acceptance test were performed for all input and notification appliances and alarm panels in accordance with NFPA 72 Table 14.3.1 and a record of completion was filled out by the contractor and turned over to me prior to system turnover and full acceptance of the building. This included ensuring that all functions listed on the sequence of operation (i.e., input/output matrix) perform as prescribed; ensuring there are no opens, shorts or grounds; ensuring appropriate sound levels in all occupied areas (i.e., minimum of 70 dBA for the temporal 3 tone generator preceded voice messaging); ensuring all strobes provide the appropriate lamination (minimum of .375 lumens/sq. ft.). PMs and surveillances are being created and are in the process of being released which are required per NFPA 72, and the NEIL Loss Prevention Manual.

5.6 System Summary
The system design follows the prescriptive requirements of NFPA 72 Notification appliances were installed and tested in accordance with the prescriptive requirements of NFPA 72-2010.
The input and notification appliances and alarms and all other related appliances have been installed and acceptance tested in accordance with NFPA 72-2010 and NFPA 70 and complies with the applicable codes and installation standards. The dual phone line which sends the trouble, supervisor, and alarm signals to the central station (which is UL listed) have been verified. In summery the building's detection and alarm system are code compliant. The suppression system that was installed in accordance with and meets the prescriptive design requirements in NFPA 101, 2009 edition and NFPA 13, 2010 edition will be discussed in section 6 below.

6.0 Suppression System:

Suppression:

Since the building is of Type III B Ordinary Hazard Group II the building is fully sprinkled with the following design bases requirements and systems:

Design Bases Requirements:

- Ordinary Hazard Group I
- Flow Density required over operation: 0.15 gpm/sq.ft. (see Figure 6 below)
- Maximum Area of sprinkler operation 1500 sq. ft.
- Hose Stream: 250 gpm

- ➢ Single riser splits into two independent risers that feed the center mains for the sprinkler system
- ➢ Flow and Pressure at base of riser with greatest demand: 487.7 gpm @ 87.4 psi per Hydraulic Calc on Tables 14 and 15 below
- ➢ Standpipe in the mechanical room fed from a class 50 underground ductile 8-inch pipe which supplies two 4 inch loops of pipe that can be put on line interchangeably
- ➢ 100 gpm hose stream for a single fire scenario
- Acceptable Flow Rate at base of riser per NFPA 13 Table 11.2.2.1: 850-1500 gpm for 60-90 min
- Total Water Required: 850 gpm for 90 min = 76, 500 gallons of water required from above ground water storage tank which is show as being met by the pump capacity of per the Pump curve in Figure 7.

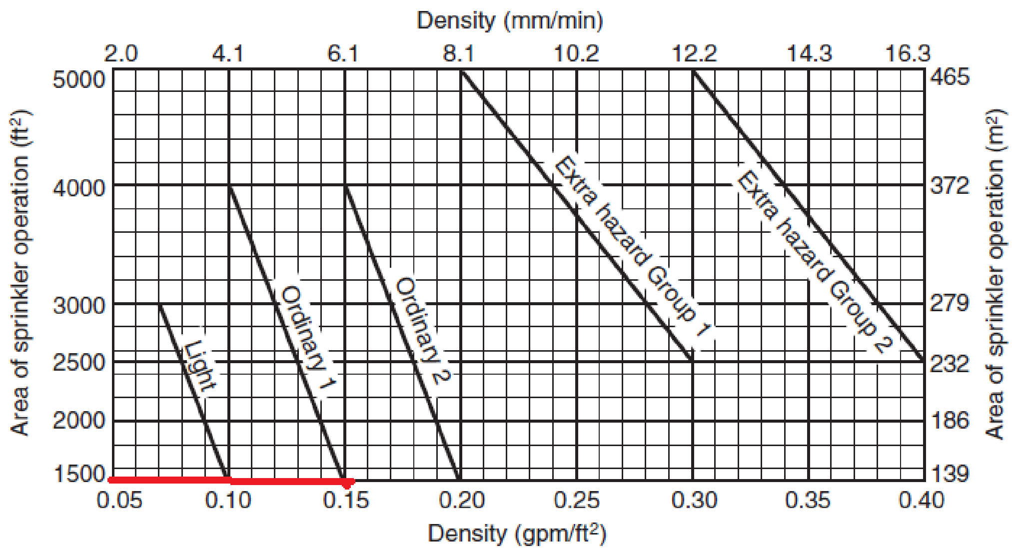

Figure 6
Density Area Curve

Fire Hydrants;

There is one fire hydrant that provides water for the Burke County Fire Department. This single fire hydrant is located 10 feet in front of Building X. The fire hydrant is a standard fire hydrant with a 4-inch outlet and national pumper thread of 2 ½ inches.

Fire Pumps:

The 1.5 HP 3 AMP Jockey pump maintains system pressure between 125 psi and 129 psi (127 psi) in an 8-inch pipe. A pre-packed, factory assembled, and tested diesel split case centrifical fire pump (complete with enclosure concrete footings and concrete pads) provides a flow rate of 850 gpm at 122 PSI to the 8-inch line. The 8-inch line exits the pump house thru an 8 inch 90-degree elbow down through an 8 inch uni-flange which is considered the point of connection to the class 50 underground ductile 8-inch pipe. This pipe connects to the standpipe in the mechanical room of building X. Note the pipe details on the piping system components are given in the General Wet Pipe System Configuration Summary in the previous section.

Controllers:

1. Firetrol Diesel Controller used for the diesel pump
2. Firetrol Jockey Pump Controller for the Jockey pump

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Step No.		Nozzle Ident and Location	Flow in gpm		Pipe Fittings and Devices	Equivalent Pipe Length(FT)		Friction loss (psi/ft)		Pressure Summary		Normal Pressure			NOTES
															Sprinklers are installed in a 10.83 ft x 10 ft
															Light Haz Design density .10 for 1500 sq ft per table 11.2.3.1.1 NFPA 13
															COVERAGE PER SPRINKLER 120 FT, AREA OF APPLICATION 1950 SQ FT.
															(16) 1/2 INCH EXTENDED COVERAGE PENDANT SPRINKLERS
1	1	200 H	q			L	10.83	C=	120	Pt	4.6	Pt		5.6	K-FACTOR
		pipe 1				F	2		0.000	Pe	0.0	Pv			q = k * (Pt)^1/2; Qi= A*D = 14.8
		2001 H	Q	12.0		T	12.83	pf	0.051	Pf	0.6	Pn			Pt= (Q/K)^2=7
2	2	201 H	q	12.8		L	10.83	C=	120	Pt	5.2	Pt		5.6	q = 5.6* (14.1)^1/2
		pipe 2				F				Pe		Pv			elevation 33.2 ft
		202 H	Q	24.8		T	10.83	pf	0.051	Pf	0.6	Pn			
3	3	202 H	q	13.5		L	10.83	C=	120	Pt	5.8	Pt		5.6	q = 5.6* (19.0)^1/2
		pipe 3				F				Pe		Pv			elevation 33.2 ft
		203 H	Q	38.3		T	10.83	pf	0.054	Pf	0.6	Pn			
4	4	203 H	q	14.1		L	9.83	C=	120	Pt	6.4	Pt		5.6	q = 5.6* (19.0)^1/2
		pipe 4				F				Pe		Pv			elevation 33.2 ft
		204H	Q	52.4		T	9.83	pf	0.096	Pf	0.9	Pn			
5	5	204 H	q	15.2		L	25	C=	120	Pt	7.3	Pt		5.6	q = 5.6* (19.0)^1/2
		pipe 5			2ET	F	16			Pe	7.9	Pv			elevation 33.2 ft
		205 H	Q	67.6		T	41	pf	0.154	Pf	6.3	Pn			
6	6	2025H	q	26.0		L	10.83	C=	120	Pt	21.5	Pt		5.6	q = 5.6* (19.0)^1/2
		pipe 6			E	F	2			Pe		Pv			elevation 33.2 ft
		206H	Q	93.6		T	12.83	pf	2.260	Pf	29.0	Pn			
7	7	206 H	q	39.8		L	10.83	C=	120	Pt	50.5	Pt		5.6	q = 5.6* (19.0)^1/2
		pipe 7				F				Pe		Pv			elevation 33.2 ft
		207H	Q	133.4		T	10.83	pf	1.145	Pf	12.4	Pn			
8	8	207 H	q	44.4		L	10	C=	120	Pt	62.9	Pt		5.6	q = 5.6* (19.0)^1/2
		pipe 8				F				Pe		Pv			elevation 33.2 ft
		208H	Q	112.0		T	10	pf	0.391	Pf	3.9	Pn			
9	9	208 H	q	45.8		L	9.83	C=	120	Pt	66.8	Pt		5.6	q = 5.6* (19.0)^1/2
		pipe 9				F				Pe		Pv			elevation 33.2 ft
		209H	Q	157.8		T	9.83	pf	0.738	Pf	7.3	Pn			
10	10	209H	q	48.2		L	25	C=	120	Pt	74.1	Pt		5.6	q = 5.6 * (22)^1/2

Table 14
Hydraulic Calculation for Riser with Greatest Demand (part 1)

11	11	210H	q	64.2		L	12.83	C=	120.000	Pt	131.5	Pt		5.6	
		pipe 11				F				Pe	1.3	Pv			elevation 33.2 ft
		211H	Q	270.2		T	12.83	pf	0.193	Pf	2.5	Pn			
12	12	211H	q	65.1		L	10.83	C=	120.000	Pt	135.3	Pt		5.6	
		pipe 12				F				Pe	1.3	Pv			elevation 33.2 ft
		212H	Q	335.3		T	10.83	pf	6.304	Pf	68.3	Pn			
13	13	212H	q	80.1		L	45	C=	1.600	Pt	204.8	Pt		5.6	
		PIPE 13			2ET	F	16			Pe	7.9	Pv			elevation 33.2 ft
		213H	Q	415.5		T	61	pf	0.202	Pf	12.3	Pn		0	
14	14	213H	q	25.2		L	12.83	C=	120.000	Pt	20.2	Pt		5.6	
		PIPE 14				F				Pe		Pv			elevation 33.2 ft
		214H	Q	25.2		T	12.83	pf	0.193	Pf	2.5	Pn			
15	15	214H	q	26.7		L	10.83	C=	120.000	Pt	22.7	Pt		5.6	
		PIPE 15				F				Pe		Pv			elevation 33.2 ft
		215H	Q	51.9		T	10.83	pf	0.199	Pf	2.2	Pn		166	
16	16	215H	q	27.9		L	45	C=	120.000	Pt	24.9	Pt		5.6	elevation 33.2 ft
		PIPE 16			2ET	F	16			Pe		Pv			
		8T	Q	79.8		T	61	pf	0.209	Pf	12.7	Pn		98.1	
17	17	5T	q	0.0		L	1.66	C=	120.000	Pt	37.6	Pt		0	
		PIPE 17				F				Pe		Pv			elevation 14.8ft
		6T	Q	119.5		T	1.66	pf	0.014	Pf	0.0	Pn			
17a	17A	6T	q	92.6		L	117	C=	120.000	Pt	37.6	Pt		0	
		PIPE 17A			4ET	F	62.79			Pe	0.1	Pv			elevation 14.8ft
		4T	Q	119.5		T	179.79	pf	0.014	Pf	2.6	Pn		0	
18	18	4T	q	119.5		L	149	C=	120.000	Pt	40.3	Pt		18.8	K=119/sqrt(40.3)=18.8
		3T			8ET	F	64			Pe	0.6	Pv			elevation 14.8ft
			Q	119.5		T	213	pf	0.014	Pf	3.0	Pn		0	q = k * (Pt)^1/2; Qi= A*D = 124.8
19	19	3T	q	124.8		L	65	C=	120.000	Pt	43.9	Pt		18.8	K VALUE CALCULATD
		7T			5E	F	47			Pe	-0.7	Pv			elevation 14.8ft
			Q	244.3		T	112	pf	0.053	Pf	6.0	Pn			
20	20	7T	q	105.9		L	1.66	C=	120.000	Pt	49.2	Pt		18.8	
		8T				F	40			Pe		Pv			elevation 14.8ft
			Q	350.2		T	41.66	pf	0.104	Pf	4.3	Pn			0
21	21	8T	q	137.5		L	109	C=	120.000	Pt	53.5	Pt		18.8	
		TOR1			3E2T	F	68			Pe		Pv			elevation 14.8ft
			Q	487.7		T	177	pf	0.192	Pf	33.9	Pn			
22	22	TOR1	q	0.0		L	13.83	C=	120.000	Pt	87.4	Pt		18.8	
		BOR			ETCG	F	71.1			Pe	5.6	Pv			elevation 2.0 ft
			Q	487.7		T	84.93	pf	0.192	Pf	16.3	Pn			

Table 15
Hydraulic Calculation for Riser with Greatest Demand (part 2)

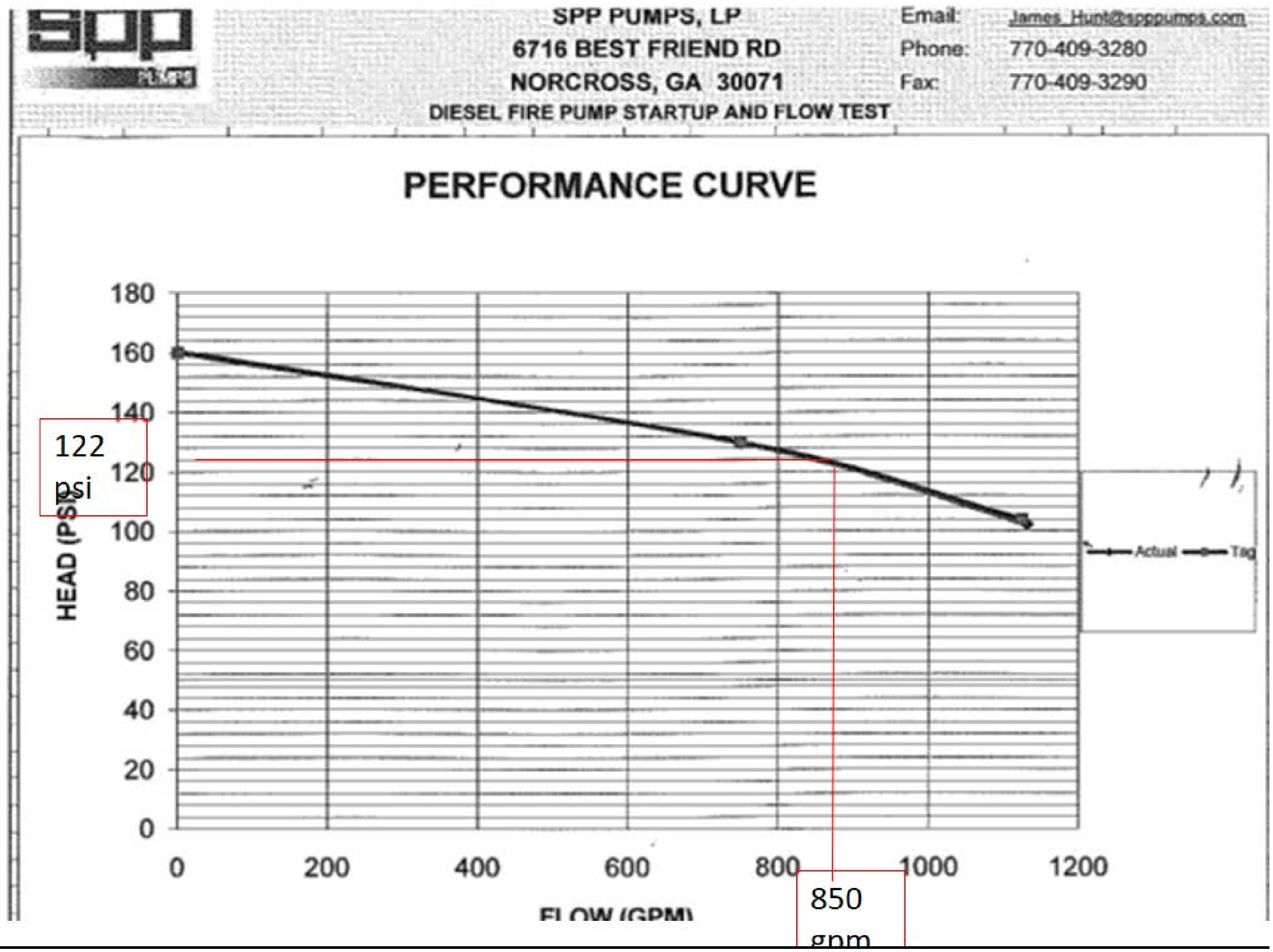


Figure 7
Diesel Fire Pump Performance Curve

An overview of the Water Based Suppression System that has been installed throughout Building X has been depicted below in Figure 9.

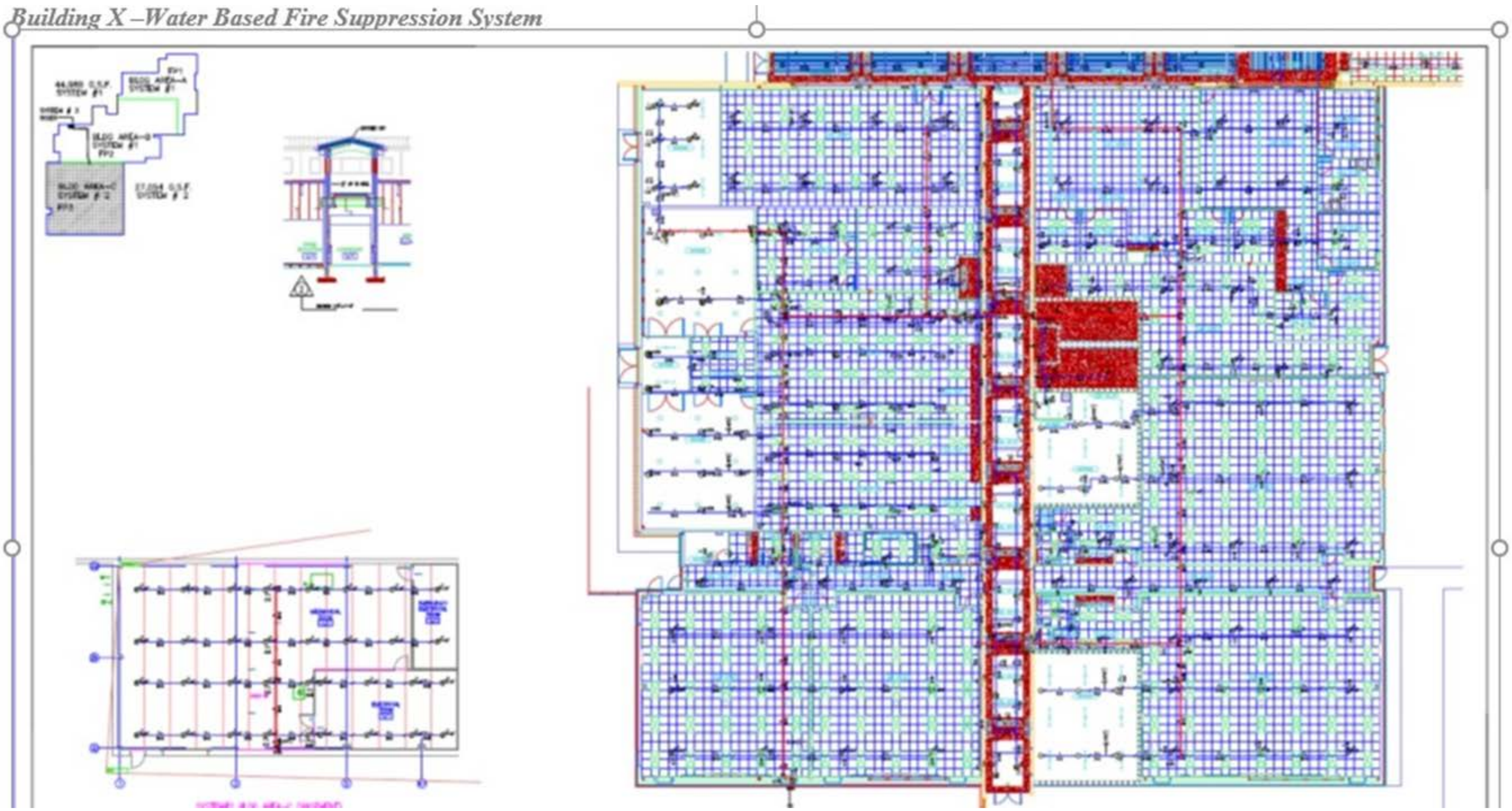


Figure 8 Overview of the Water Based Suppression System

General Wet Pipe System Configuration Summary:

The water for the wet pipe suppression system is supplied from a fire water storage tank located approximately 100 yards from the Building X. The water flows from the fire water storage tank, which is at ground level, through an 8-inch ductile underground pipe though the 8-inch fill pipe inside the heated enclosed pump house constructed and maintained in accordance with NFPA 20. The water then flows through an 8 inch pipe through the diesel fire pump that can meet the capacity of 805 gpm at 122 PSI through a 4 inch relief valve, through an 8 inch wafer check valve, through a section of pipe accessed by a test header, through the electric jockey pump, through a potter flow switch, through an 8 inch control valve, through a Tee for an 8 inch recirculation line (which has an 8 inch control valve with tamper switch and a check valve), through an 8 inch DCDA backflow preventer, through an 8 inch OS&Y control valve with tamper switch, and out of the pump house down through 8 inch pipe and through an 8 inch uniflange.

There is test connection port that extends the pump house. Both pumps controllers are set for both respective pumps to start in automatic mode. The jockey pump maintains system pressure of the underground pipe from the pump house to the standpipe in the mechanical room of building X between 125 psi and 129 psi. When the pressure falls below 117 psi the diesel pump will kick on until it is shut off manually or until pump failure occurs as prescribed in NFPA 20. The pump house where the diesel and jockey pumps are housed is also protected by a sprinkler system.

The standpipe in the mechanical room is fed from a class 50 underground ductile 8 inch pipe (that has two free standing fire department connection hose threads to match the connections of the local fire department) which supplies two 4 inch loops of pipe that can be put on line interchangeably, each respective line has a wall post indicating control valve with tamper switch, alarm check valve assembly, pressure gauge, Potter valve type water flow alarm flow switch that is connected to fire alarm panel and a 2 inch elbow that supply the 2 inch cross main lines.

There is a single riser that splits into two independent risers which feed the center mains for the sprinkler system with the required water capacity. In addition, there is a single 2-inch drain to the outside, and a retard chamber, connected to a water motor going drain to the outside. Actuation of the flow meter and or a pull alarm will alert personal to evacuate the building and send a signal to the panel located in the main corridor which is transmitted to a secondary responder who contacts Burke County fire department and the control room simultaneously. The system defined above satisfy the following LSC requirements: **7.14.4.1** The building shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with 9.7.1.1(1), except as otherwise specified in 7.14.4.2. and **7.14.4.1.1** a sprinkler control valve and a water flow device shall be provided for each floor. **7.14.4.1.2** The sprinkler control valves and water flow devices required by 7.14.4.1.1 shall be monitored by the building fire alarm system.

The 2 inch cross main lines supplies 1-inch branch lines. The sprinkler branch lines supply 1-inch orifice quick response upright and recessed pendent sprinklers are supplied (with water from the 1-inch branch lines) used in the main corridors. All other rooms have 1-inch orifice glass bulb pendant sprinklers supplied by 1-inch branch line. All branch lines are composed of ASTM 135 electric-resistance-welded seamless pipe in accordance with NFPA 13 table 6.3.1.1.

6.1 Water Supply Source and Flow Path for Water Based Sprinkler System

Ground Level Fire Water Storage Tank:

The water supply source for building is provide from a 101,153 gallons ground level fire water suction tank with a diameter of 32 ft. and 8 inches, is 16 feet tall, and is separated by 20 feet of underground from the connection point to the suction line where the 8-inch ductile iron pipe enters the heated pump house. This fire water storage tank is supplied with water pumped from a municipal water source by an electric pump (that can be ran in automatic mode but currently is turned on manually since the level indicator is not connected to the pump controller) from an 8 Inch ductile iron pipe located 5 feet outside the pump house.

Liquid Height: 15.620 ft.
Material Construction: Carbon Steel
Design standard AWA D103-97/NFPA 72
Pressure 2.00 oz./ sq. in.
Vacuum 0.50 oz./sq. in
Wind Velocity: 100 mph
Wind design AWWA
Deck Live load 25 PSF
Seismic zone 2a
Use factor I=1.25
Force reduction=3.50
Site application S=150
Tank bottom: 10 gauge
Roof material: 12 gauge
Tank Dead Load: 0.131 Kips/Ft
Deck live load: 0.136 Kips/Ft
Base Shear(wind): 9.482 kips
Overturning moment (wind): 76.428 Kip-Ft
Tank uplift:0
Base Shear(seismic): 86.122 Kips
Overturning moment (seismic): 607.366 kips/ft.
Tank Uplift(seismic): 0
Bottom pressure from contents: 972 psf
Center support Axial Load DL + LL: 9.07 Kips

Tank components are as follows:

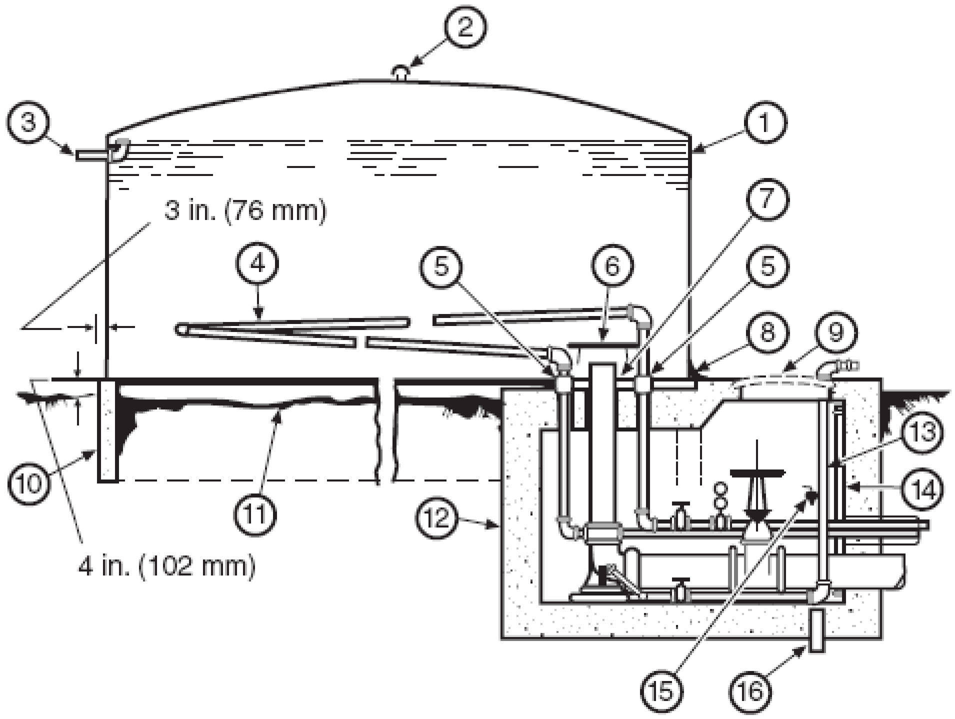


Figure 9
Above Ground Fire Water Storage Tank

In addition, a cable/float water level indicator is located on the side wall of the tank.

<u>Seismic Protection:</u>
This fire protection system and the building it provides protection for is located in Waynesboro Georgia, where there is no danger of earthquakes. There are no other extraordinary forces exerted on the fire water storage tank beyond the ordinary dead load and nominal wind loads.

1. Pump suction tank
2. Screened vent
3. Stub overflow pipe
4. Steam coil for heating
5. Extra-heavy couplings welded to tank bottom
6. Vortex plate
7. Watertight lead slip joint
8. Flashing around tank
9. Manhole with cover
10. Concrete ring wall
11. Sand or concrete pad (depending on soil condition)
12. Valve pit
13. Drain pipe
14. Ladder
15. Drain cock
16. Valve pit drain

<u>Freeze Protection for the Fire Water Storage Tank:</u>
Although the temperatures on rare occasions have been known to drop below freezing, which would result in freeze protection being warranted, currently there is no freeze protection for the fire water storage tank.

Coating:
As required per NFPA 22 cathodic protection was applied to the inner walls and the bottom of the tank to protect the integrity of the bottom of the tank in addition to the side walls of the tank.

Total Head of Pressure:
Total Head of Pressure resulting from the head from the 16-foot elevation of the fire water storage tank of 16 feet acting at the point where 8-inch line exiting the pump house thru the 8 inch 90-degree elbow connects to the uniflange is defined as follows:

$P_t = P_n + P_v$

$P_{n(static)} = 0.433\ h_p = 0.433(16\text{ feet}) = 6.928 = 7\text{ psi}$

$P_{n(residual)} = 0.433\ \frac{V^2 \quad = 6.0\text{ psi}}{2g}$

Where v= $2\sqrt{gh} = 2\sqrt{(32.2\text{ ft./sec})\ (\text{feet})}$

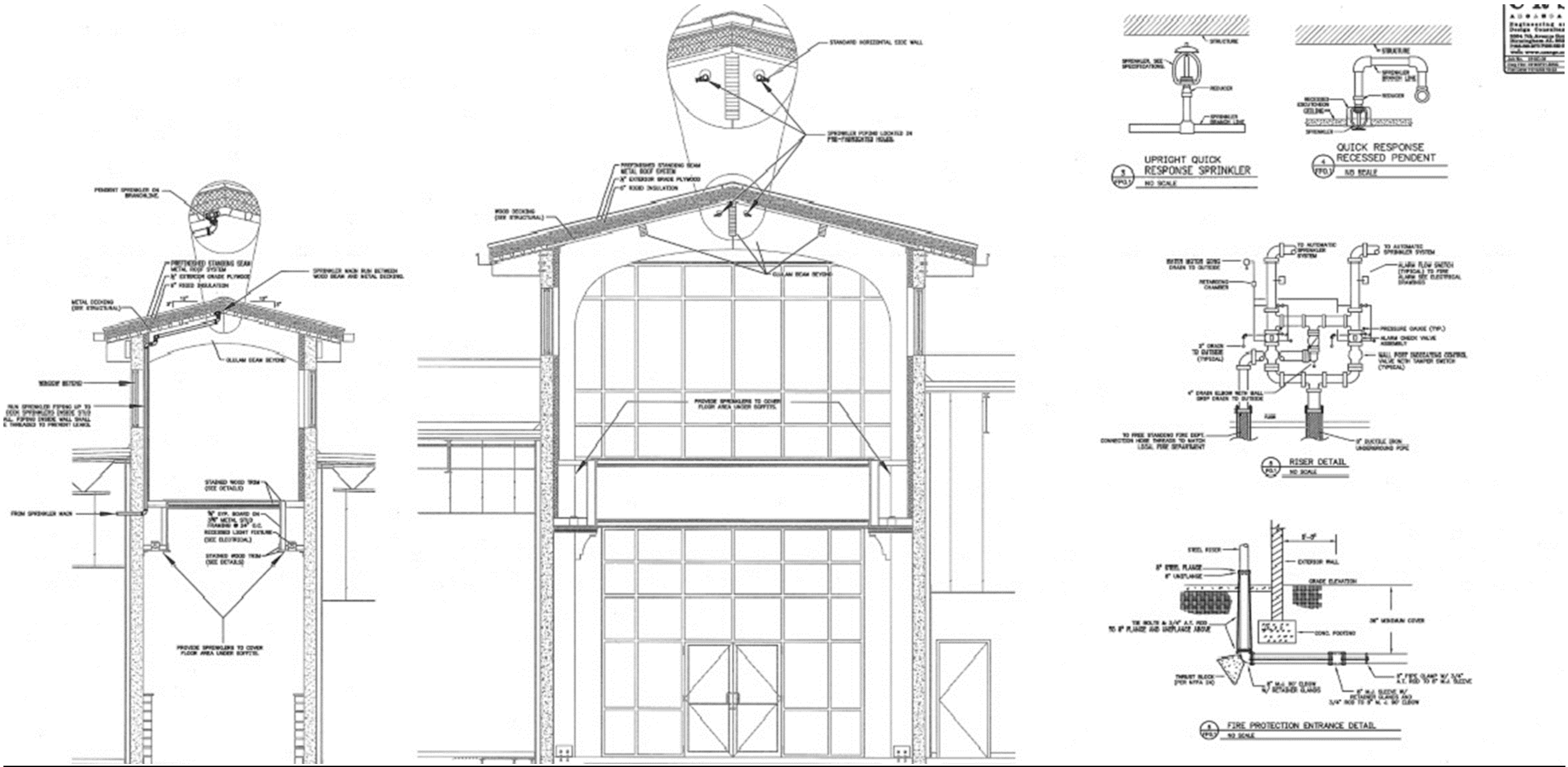


Figure 10
Wet Pipe Sprinkler System

Construction:

- Fire retardant treated wood in the atrium
- 75,674 sq.ft.

Front (North) Entrance to Atrium

Main Corridor or Atrium for Main Entrance

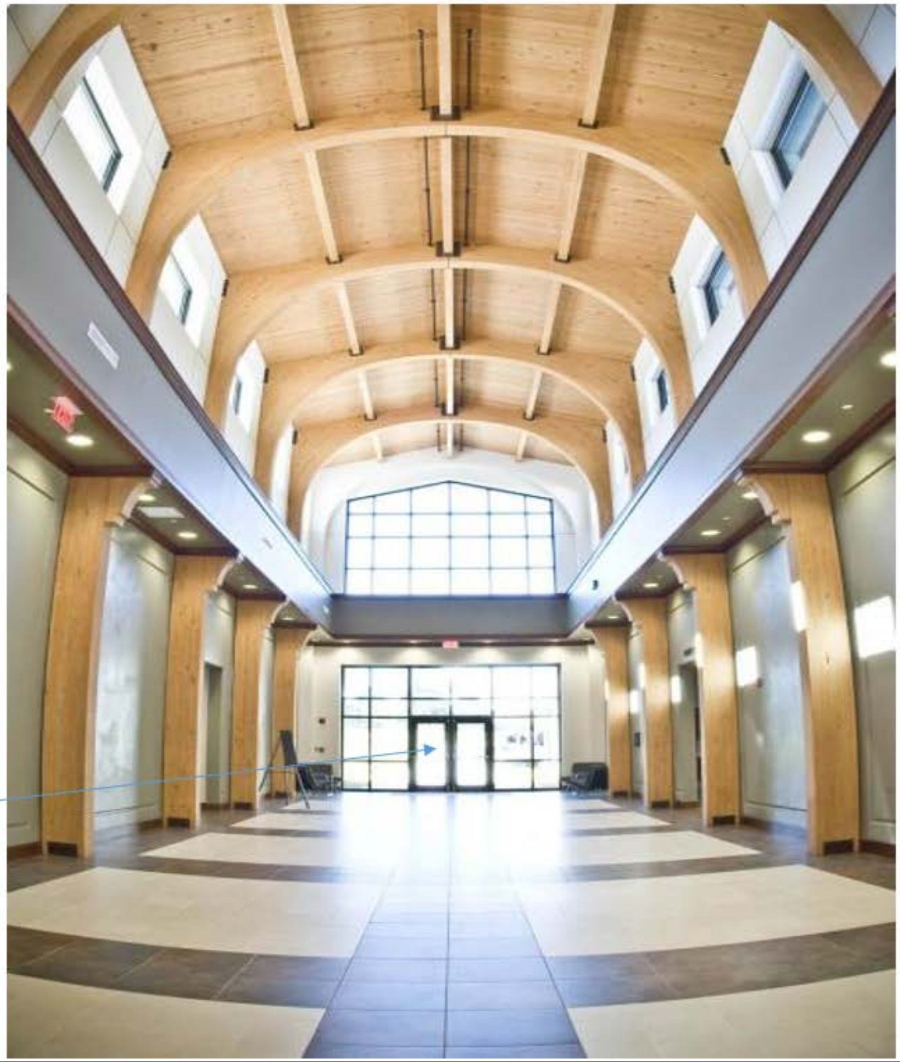


Figure 11
Main Corridor

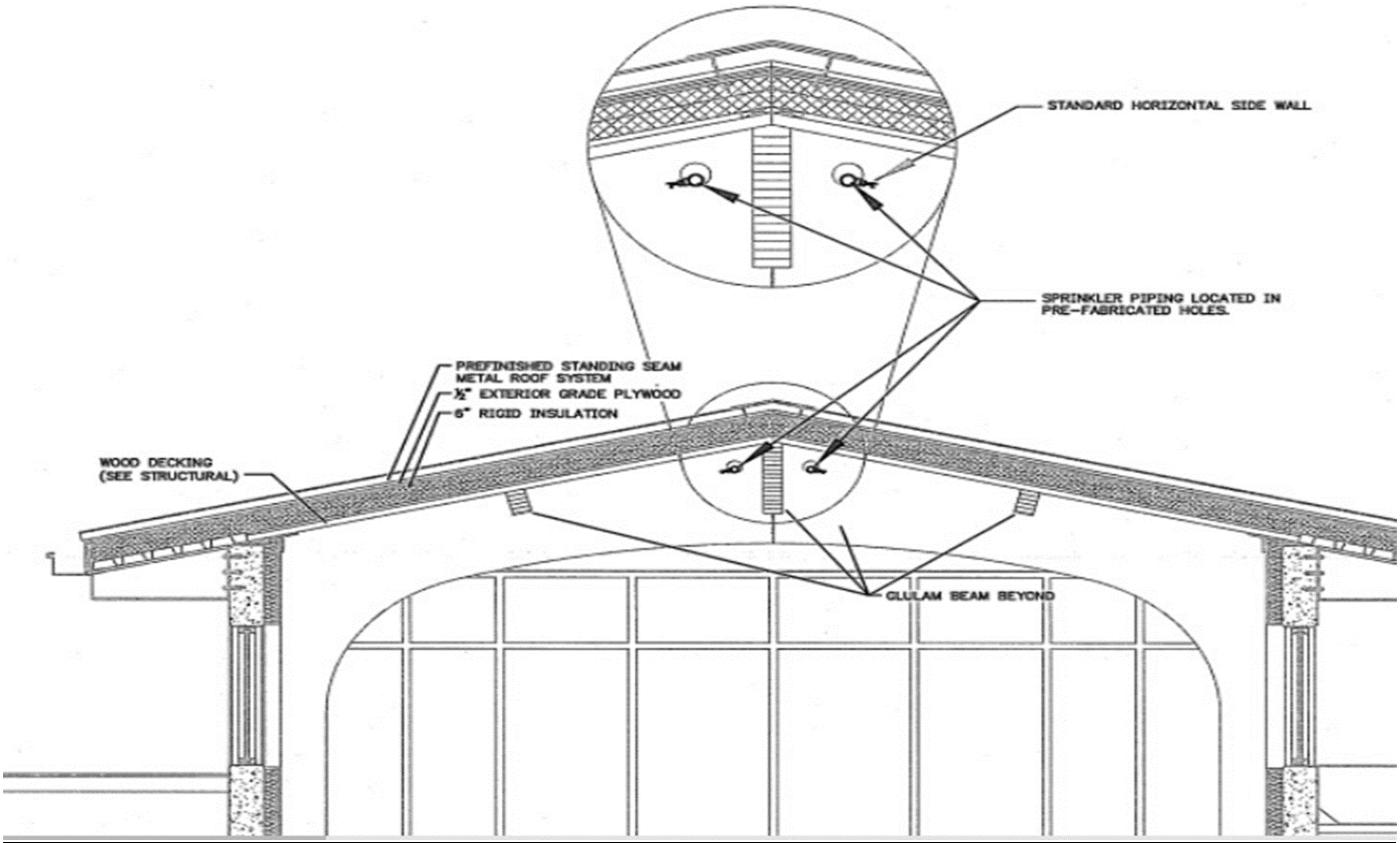
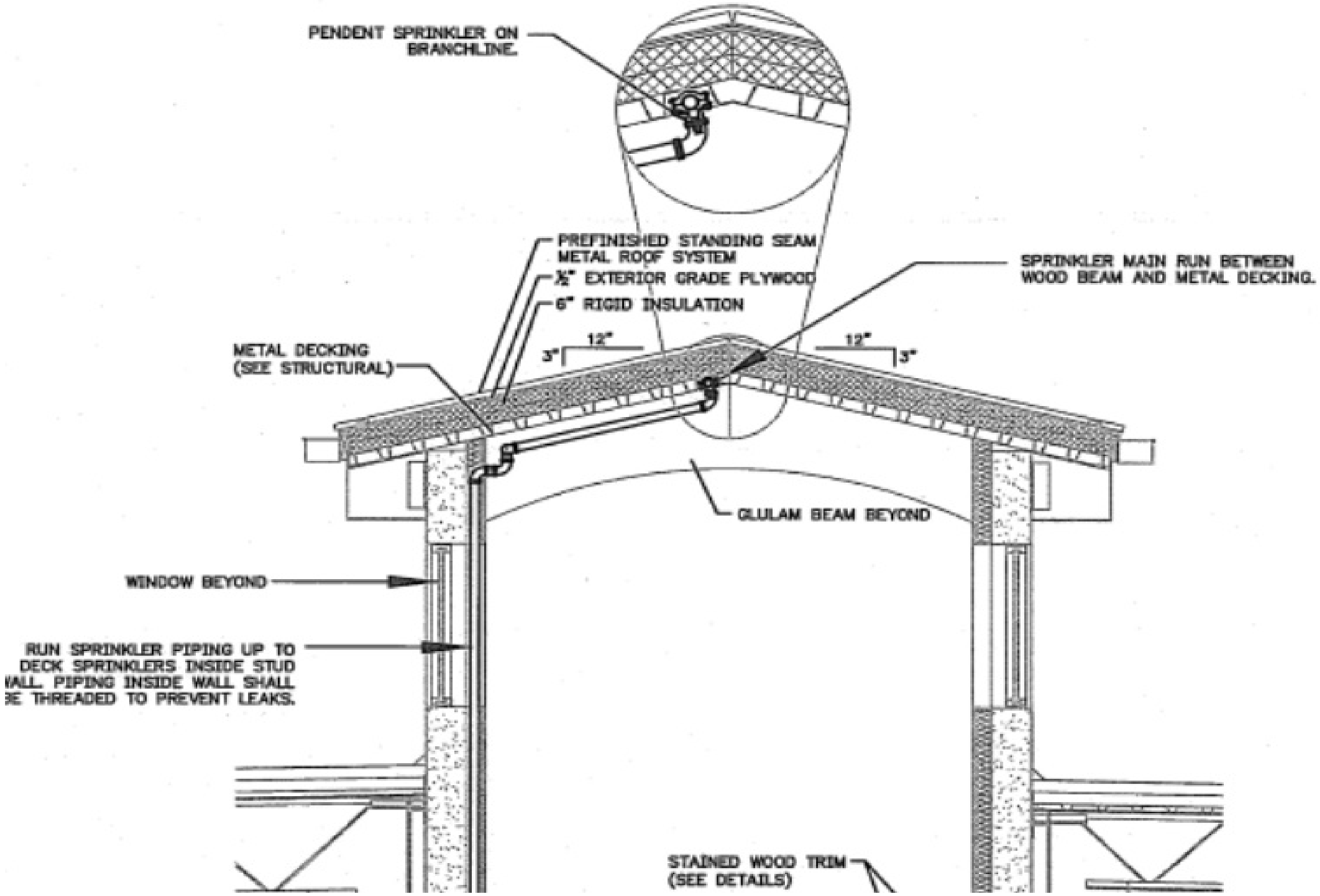


Figure 12 Sprinkler System Detail for Main Corridor Page 1



Jockey Pump and Diesel Fire Pump:

Figure 13 Sprinkler System Detail for Main Corridor Page 2

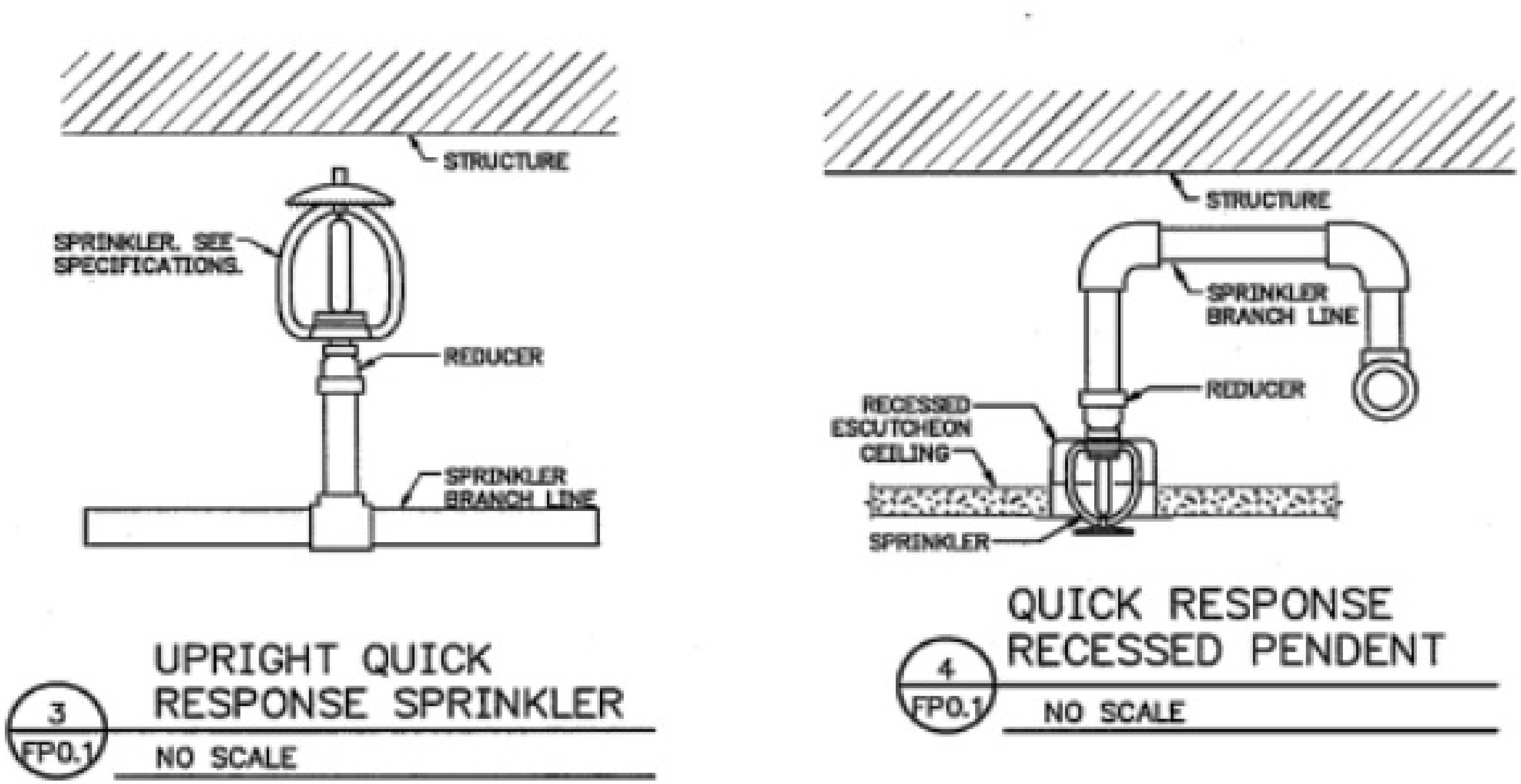


Figure 14 Sprinkler Types Used in Building X

6.2 Special Suppression System Design:

NEIL's Loss Control Standards Section 3.2.20.5 states automatic fixed extinguishing systems "should" be provided for: 15. High Value Electronic Equipment Rooms. Since this is a "should" statement and NEIL opposed to a "Shall" statement suppression system is not required, however if a sprinkler system was not installed an increase in the insurance premium for the plant would have been incurred to cover the additional risk to NEIL [Ref: 5]

Aspirated smoke detection (or "air-sampling smoke detection" (ASD)) systems for open-area protection, aspirated systems comprised of pipes laid out below the ceiling in parallel runs, some meters apart. Small holes, also some meters apart, were drilled into each pipe to form a matrix of holes ('sampling points'), providing an even distribution across the ceiling. Air or smoke is drawn into the pipework through the holes and onward to a very sensitive smoke detector mounted nearby, using the suction pressure of an aspirator/fan or air pump. Server cabinet protection -flexible capillary tubes were fed through sampling points in each server cabinet which are separated internally from each other structurally so the Vesda nodes can be used to detect pre-ignition individually as zones within separated cabinets. The VESDA aspirated smoke detector is a refined form of air pollution monitor, which has sensitivity several hundreds of times higher than conventional smoke detectors, yet due to quality of design, optics and electronics its false alarm rate is exceptionally low.

VESDA detectors monitor for the early symptoms of overheating materials, and provide early indications of thermal events and fire risks possibly hours before a fire develops.

In this way, very early warning allows plenty of time for human intervention, or automatic intervention by the operation of an electric circuit breaker for example (which removes the source of heat - electric current).

Automatic suppression was provided since the equipment in Building X is valued well beyond 1 million dollars and in lieu of the should requirement for automatic detection for buildings or rooms that are valued at or contain valuables in excess of $500,000. Therefore, no insurance premium was assumed by the plant. Novec 1230 a new clean agent was used as suppression in certain in cabinets and Novec 1230 extinguishers have been provided for room suppression where these cabinets are located and have incipient detection installed to alert personal of possible fires prior to incipient stage. Novec 1230 Fire Protection Fluid is a highly-effective clean agent fire suppressant, designed to control and extinguish a fire in its incipient stage before it has a chance to spread. Novec 1230 It interferes with the combustion process, stopping a fire in its pre-combustion stage. Novec 1230 fluid will extinguish a fire. Novec 1230 fluid actually changes from a liquid to a gas because it has a very low heat of vaporization, approximately 25 times less than that of water. As a result, Novec 1230 fluid evaporates more than 50 times quicker than water. This allows the fluid to transition from a liquid to a gaseous state very rapidly when discharged through a nozzle. In a properly designed system, Novec 1230 fluid will quickly vaporize and evenly distribute itself throughout the space being protected. The server cabinets in the server room and the additional two other electrical rooms themselves maintain doors in closed positions by administrative controls. Therefore, a minimum design concentration of 85 percent can be held at the highest level of combustibles for a minimum period of 10 minutes in accordance with 2008 edition of NFPA 2001, paragraph 5.6.

6.3 Suppression System Design Summary:

In summary a wet pipe automatic sprinkler suppression system has been installed throughout Building X except in the server room and two other rooms that cannot be designated for security reasons.

The water for the wet pipe automatic sprinkler suppression system is supplied from a ground level fire water storage tank located approximately 100 yards from Building X. The water flows from the fire water storage tank through an 8-inch ductile underground pipe though the 8-inch fill pipe inside the heated enclosed pump house. The water then flows through an 8 inch pipe through the diesel fire pump that can meet the 122 PSI and 850 gpm required capacity, through a 4 inch relief valve, through an 8 inch water check valve, through a section of pipe accessed by a test header, through the electric jockey pump, through a potter flow switch, through an 8 inch control valve, through a Tee for an 8 inch recirculation line (which has an 8 inch control valve with tamper switch and a check valve), through an 8 inch DCDA backflow preventer, through an 8 inch OS&Y control valve with tamper switch, and out of the pump house down through 8 inch pipe and through an 8 inch uniflange.

Both pump controls are set and maintained in automatic mode and maintain the system pressure of the underground pipe from the pump house to the standpipe in the mechanical room of Building X between 125 psi and 129 psi. When the pressure falls below 117, psi the diesel pump will kick on until it is shut off manually or until pump failure occurs as prescribed in NFPA 20. The pumps is capable of meeting the 850 gpm at 122 psi performance requirement which will meet the requirement of riser with the most demand of 487.7 gpm @ 87.4 psi + a 250 gpm hose stream.

The standpipe in the mechanical room is fed from a class 50 underground ductile 8-inch pipe which supplies two 4 inch loops of pipe that can be put on line interchangeably. Each respective line has a wall post indicating control valve with tamper switch, alarm check valve assembly, pressure gauge, Potter valve type water flow alarm flow switch that is connected to fire alarm panel and a 2-inch elbow that supply the 2 inch cross main lines.

There is a single riser that splits into two independent risers which feed the center 2-inch cross mains for the sprinkler system with the required water capacity. In addition, there is a single 2-inch drain to the outside, and a retard chamber. Actuation of the flow meter or a pull alarm will alert personal to evacuate the building and send a signal to the panel located in the main corridor which is transmitted to a secondary responder who contacts Burke County fire department and the control room simultaneously.

The 2 inch cross main lines supplies 1-inch branch lines. The sprinkler branch lines supply 1-inch orifice quick response upright and recessed pendent sprinklers. These sprinklers are used in the main corridors. All other rooms have 1-inch orifice glass bulb pendant sprinklers supplied by 1-inch branch lines. All branch lines are composed of ASTM 135 electric-resistance-welded seamless pipe in accordance with NFPA 13 table 6.3.1.1.

The water supply source for building is provide from a 101,153 gallons ground level fire water suction tank with cathodic protection in its inner walls and the bottom of the tank.

Novec 1230, a new clean agent, was used as suppression in certain in cabinets. Novec 1230 extinguishers have been provided for room suppression where these cabinets are located in the server room and the two un-disclosed rooms mentioned above. Incipient detection has been installed to alert personal of possible fires prior to incipient stage.
Next in section 7 the Transient Combustible and Hot Work Permit Program will be discussed.

7.0 Transient Combustible and Hot Work Controls
Tipple Tech Software will be used to submit, approve, and maintain transient combustibles and hot work permits. This software provides an employee the capability to submit and have a transient combustible or hot work permit approved in an hour and defining any required compensatory actions. In addition, the software provides a 3D model of facility; locations where transient combustible and hot work have been stored and is being conducted respectively. The software maintains and updates the heat release rates in KW and ensures that it does not exceed the predetermined ranges for the respective zone.

Transient combustibles materials and hot work permit are prohibited unless a transient combustible permit has been submitted and approved in the Tipple Tech Software the combustibles are stored inside the appropriate transient combustible cabinets located in the designated area (i.e. file cabinets, space savers, storage lockers). Limiting fire loading is an important fundamental characteristic for safeguarding occupant life safety [LSC 4.5.2] [Ref: 1].

7.1 First Responders and Manual Fire Suppression
Burke County Fire Department is the primary responder to fire alarms for this Facility. Burke County Fire department receives a phone call from a third party monitoring company once they receive an alarm from the primary alarm panel located in the main corridor. In addition, portable fire extinguishers have been installed in accordance with NFPA 10 at the prescribed locations.

<u>Summary of Deficiencies:</u>
No design deficiencies were identified.

8.0 Maintenance, Testing, and Inspection for Building X Detection, Suppression, and Water Supply Systems

Granted that main drain and flow test, and preventive maintenance is schedule and performed in accordance with applicable vendor manuals and NFPA,13, 25, and NFPA 20 requirements it can be assumed that the FP system for Building X will maintained to function as designed and provide the protection it was qualified for during system acceptance testing.

NOTE: Although the scope of work for inspection, test, or maintenance task are the same as depicted in NFPA 25 (2002), NFPA 1962 (2003), NFPA 72 (2002), and NFPA 10 (2002) the frequencies for these tasks for the components listed below are in accordance with the NEIL (the AHJ and insurer of the property) Loss Controls Standards Chapter 4 Requirements which supersedes the NFPA requirements for building X and all buildings being constructed at the plant. The frequency for major evolutions are general 18 months which coincides with the plants planned refueling cycle (outages).

Only the components that exist for building X's system have been listed, thus the reason for skipping in category numbers in the below listed tables.

A. Fire Mains/Hydrants

Below in Table 16 Maintenance, Test, and Inspection Requirements for Hydrants based on NFPA 25 (2002) Chapter 7; NFPA 1962 (2003) Chapter 4 and Chapter 7 has been provided.

Table 16 Maintenance, Test, and Inspection Requirements for Hydrants

Category	Component	Activity	Acceptable Neil Frequency
A.1	Hydrants	Inspect	Annual
A.2	Hydrants	Maintain	Annual
A.3	Hydrants	Test Flow	Annual
A.7	Underground Mains	Flow Test	5 Years

A summary of maintenance, test, and inspections for the aforementioned category a component is listed below:

A.1. Hydrants need to be inspected annually and after each operation and the necessary corrective actions taken for the items described below:

· Accessibility of the Hydrant
· Leaks in outlets or top of the hydrant
· Damage to the hydrant barrel
· Worn threads or operating nut
· Availability of hydrant wrench
· For Dry Barrel Hydrants determine proper barrel drainage by checking for water in the barrel prior to freezing weather

A.2. Hydrants need to be lubricated annually to ensure that all stems, caps, plugs, and threads are in proper operating condition.

A.3. Hydrants need to be tested annually to ensure proper functioning. Each hydrant needs to be opened fully and water flowed until all foreign material has cleared. Flow needs to be maintained for not less than one minute.

After operation, dry barrel and wall hydrants need to be observed for proper drainage from the barrel. Full drainage normally does not take longer than 60 minutes. Where soil conditions or other factors are such that the hydrant barrel does not drain within 60 minutes or where the groundwater level is above the hydrant drain, the hydrant drain is usually plugged and the water in the barrel is pumped out. Dry barrel hydrants located in areas subject to freezing weather and that have plugged drains need to be clearly identified as needing to be pumped out after operation.

A.7. Underground and exposed piping need to be flow tested to determine the internal condition of the piping at minimum five-year intervals. Flow tests need to be performed at flows representative of those expected during a fire for the purpose of comparing friction loss characteristics of the pipe with that expected for the particular type of pipe involved, with due consideration given to the age of the pipe and to the results of previous flow tests. Any flow test results that indicate deterioration of available water flow and pressure need to be fully investigated to ensure that adequate flow and pressure are available for fire protection.

B. Water Storage Tanks

Below in Table 17 Water Storage Tank Testing Requirements based on NFPA 25 (2002) Chapter 9 have been provided.

Table 17 Water Storage Tank Testing Requirements

Category	Component	Activity	Acceptable Neil Frequency
B.1	Tank Exterior	Inspect	Annual
B.2	Tank Interior	Inspect	5 Years
B.4	Water Level	Inspect	Monthly
B.5	Water Level Indicators	Test	5 Years
B.6	High / Low Level Alarms	Test	18 Months

A summary of maintenance, test, and inspections for the aforementioned category B components are listed below:

B.1. The exterior of the tank, supporting structure, vents, foundation, condition of the water in the tank, and catwalks or ladders, where provided, need to be inspected annually instead of the NFPA recommended quarterly for signs of obvious damage or weakening.

B.2. The interior of tank needs to be inspected every five years. Regardless of Corrosion protection or pressurization as discussed in the exceptions in the NFPA Standard. NEIL may ACCEPT a 10-year frequency when an impressed current cathodic protection system is present and maintained.

B.4. The water level and the condition of the water in the tank shall be inspected monthly. A quarterly inspection is allowed when the low level alarms are monitored in a constantly attended location.

B.5. Level indicators need to be tested every 5 years for accuracy and freedom of movement.

B.6. High and low water level alarms need to be tested once every 18 months instead of the semiannual test recommended by NFPA.

C. Fire Pumps
Below in Table 18 Maintenance, Test, and Inspection Requirements for Pump Testing based on NFPA 25 (2002) Chapter 8 and Chapter 12 have been provided.

Table 18 Maintenance, Test, and Inspection Requirements for Pump

Category	Component	Activity	Acceptable Neil Frequency
C.1	Pump House	Inspect	Monthly
C.2	Gauges	Inspect	Monthly
C.3	Gauges	Test Calibrate	5 years
C.4	Controller Auto On	Inspect	Monthly
C.5	Diesel Driver, Oil Cooler, etc.	Inspect	Monthly
C.6	Batteries	Inspect	Quarterly
C.8	Diesel Motor	Run-30 Minutes	Monthly
C.9	Full Flow Discharge	Test	18 Months
C.10	Relief/Recirc Valve Operator	Test	18 Months
C.11	Day Fuel Tank Quantity	Inspect	Monthly
C.12	Remote Alarms	Test	18 Months
C.13	Diesel Fuel	Stored Fuel Quality	Quarterly
C.14	Discharge Check Valves	Inspect-Internal	**In Accordance with ASME OM Code - 1998**
C.15	Fire Pump / Driver	Maintain	Applicable Manufacturers Recommendation

A summary of maintenance, test, and inspections for the aforementioned category C components is listed below:

C.1. The pertinent visual observations listed in the following checklist needs to be performed monthly instead of the NFPA recommended weekly performance.
Monthly Inspection /Observations:
Pump House Conditions
Heat adequate, not less than 40° F (4.4° C) - (70° F (21° C) for pump room with diesel pumps without engine heaters)
Ventilating louvers free to operate
Pump System Conditions
Piping is free of leaks
Suction reservoir full

Electric System Conditions
Transfer switch normal pilot light illuminated
Isolating switch closed - standby (emergency) source
Reverse phase alarm pilot light off, or normal phase rotation pilot light on
Oil level in vertical motor sight glass normal

Diesel Engine System Conditions

All alarm pilot lights off

C.2. On a monthly basis verify, where appropriate, pump suction pressure and fire system pressure are in their expected bands.

C.3. The accuracy of pressure gauges and sensors used to verify that a fire pump can meet its design requirements need to be checked every 5 years for NEIL.
NFPA suggests that a preventative maintenance program be established on all components of the pump assembly in accordance with the manufacturer's recommendations. Records need to be maintained on all work performed on the pump, driver, controller, and auxiliary equipment.
In the absence of manufacturer's recommendations for preventive maintenance, NFPA 25 Table

5-5.1 provides alternative requirements, NEIL has adopted item A.3 of this table to ensure that where installed instruments are used to verify pump performance, accurate readings are obtained.

C.4. Verify on a monthly basis that the controller pilot light (power on) is illuminated and the controller selector switch is in the AUTO position.

C.5. Visual inspection of the diesel fire pump driver to verify the engine run time meter is reading, oil level in right angle drive is normal, crankcase oil level is normal, cooling water level is normal, electrolyte level in batteries is normal, water jacket heater is operating. These inspections need to be performed on a monthly basis for NEIL instead of the NFPA's suggested weekly frequency.

C.6. The diesel fire pump batteries need to be inspected for normal voltage reading, charging current readings in the normal range, and the battery pilot light are on or battery failure lights are off.
NEIL requires this inspection to be performed on a quarterly basis instead of the NFPA's suggested weekly frequency. The procedure needs to contain guidance for a material condition inspection to identify conditions such as discoloration of the electrolyte that could be an indication of end of life. EPRI 1006756, Fire Protection Surveillance Optimization and Maintenance Guide, contains an ACCEPTABLE method on meeting these requirements.

C.8. Diesel engine driven pump assemblies need to be tested without flowing water. This test needs to be conducted by automatic starting the pump for a minimum of a 30 minutes run on a monthly basis instead of NFPA's suggested weekly frequency. A valve installed, to open, as a safety feature may be permitted to discharge water.

C.9. A flow test of each pump assembly needs to be conducted under minimum, rated, and peak flows for the fire pump. The test may be performed using the fire pump test header through play pipes or through a flow meter with discharge to a drain or water supply. NEIL requires that this test be conducted every eighteen months instead of the NFPA recommended annual frequency. NEIL does NOT require the water supply to be dumped to a drain on a three-year frequency when a bypass meter discharging back to the supply tank is used.

C.10. During the fire pump flow test required in C.9 the relief valve, relief and re-closure settings need to be verified to be correct. This verification needs to be performed at an 18-month frequency to meet NEIL Standards.

C.11. The Diesel fuel tank needs to be verified to be at least 2/3 full on a monthly basis to meet NEIL Standards.

C.12. Verify for proper operation and confirm proper identification under a fault condition for fire pump alarms reporting to the control room every 18 months to meet NEIL Standards.

C.13. Long-term storage for diesel fuel is defined as storage of fuel for longer than 12 months after it is received by the user. A successful program to maintain fuel quality includes monitoring bulk fuel during prolonged storage and replacement of aged fuel with fresh product at established

intervals.
Stored fuel “should” be periodically sampled and its quality assessed. ASTM D-4057 provides guidance for sampling. Since fuel contaminants and degradation products will usually settle to the bottom of a quiescent tank, a “Bottom” or “Clearance” should be included in the evaluation. Fuels that have undergone mild-to-moderate degradation can be consumed per manufacturer’s instructions. Fuels containing very large quantities of fuel degradation products require special attention.

C.14. Inspections of Discharge Check Valves, to ensure that the check valve will perform its design function, are performed by meeting the requirements of ASME OM Code Appendix II, Check Valve Condition Monitoring Program. The program will include a sample disassembly program for valves in the same valve group as the Fire Pump Check Valves.
OR
Check valves need to be inspected internally every five years to verify that all components operate properly, move freely, and are in good condition.

C.15. Preventive maintenance needs to be conducted in accordance with applicable manufacturer’s recommendations. It is anticipated that the maintenance will include items such as changing of lubrication oil, checking of hose on engines, changing coolant on engines, and packing the pump. EPRI 1006756, Fire Protection Surveillance Optimization and Maintenance Guide contains an ACCEPTABLE method on meeting these requirements.

D. Wet Pipe Sprinkler
Below in Table 19 Maintenance, Test, and Inspection Requirements for Category D Components based on NFPA 25 (2002) Chapter 5, Chapter 10, and Chapter 12 have been provided.

Table 19 Maintenance, Test, and Inspection Requirements for category D components

Category	Component	Activity	Acceptable Neil Frequency
D.1	Sprinklers	Inspect-Visual	18 Months
D.2	Piping	Inspect-Visual	18 Months
D.3	Hanger/Seismic Bracing	Inspect-Visual	18 Months
D.4	Fire Dept. Connection	Inspect	18 Months
D.5	Water Flow Alarm (2)	Test	18 Months
D.6	System Main Drain (2)	Test	18 Months

A summary of maintenance, test, and inspections for the aforementioned category D components are listed below:
D.1. Sprinklers need to be inspected from the floor level every 18 months. Sprinklers need to be free of corrosion, foreign materials, paint, and physical damage and be installed in the proper orientation (e.g., upright, pendant, or sidewall). Any sprinkler that is painted, corroded, damaged, loaded, or in the improper orientation needs to be replaced. Sprinklers installed in concealed spaces are not required to be inspected. Sprinklers that become accessible due to maintenance or shutdown need to be inspected. Conditions identified as NOT meeting installation requirement or as listed above need to be documented and repaired.

D.2. Sprinkler pipe and fittings need to be inspected from the floor level every 18 months. Pipe and fittings need to be in good condition and free of mechanical damage, leakage, corrosion, and misalignment. Sprinkler piping is not to be subjected to external loads by materials either resting on the pipe or hung from the pipe. Pipe and fittings installed in concealed spaces are not required to be inspected. Pipe and fittings that become accessible due to maintenance or shutdown need to be inspected. Conditions identified as NOT meeting installation requirement or as listed above need to be documented and repaired.

D.3. Sprinkler pipe hangers and seismic braces needs to be inspected from the floor level every 18 months. Hangers and seismic braces need to be verified to not be damaged or loose. Hangers and seismic braces that are damaged or loose need to be replaced or refastened. Hangers and seismic braces installed in concealed spaces are not required to be inspected. Hangers and seismic braces that become accessible due to maintenance or shutdown need to be inspected. Conditions identified as NOT meeting installation requirement or as listed above need to be documented and repaired

D.4. Fire Department connections need to be inspected once every 18 months to meet NEIL Standards instead of NFPA's suggested quarterly. The inspection needs to verify the following:
· The fire Department connections are visible and accessible.
· Couplings or swivels are not damaged and rotate smoothly.
· Plugs or caps are in place and not damaged.
· Gaskets are in place and in good condition.
· Identification signs are in place.
· The check valve is not leaking.
· The automatic drain valve is in place and operating properly.

M. Alarm Signaling Systems
Below in Table 20 Alarm Signaling Systems Testing Requirements based on NFPA 72 (2002) Chapter 10 have been provided.

Table 20 Alarm Signaling Systems Testing Requirements

Category	Component	Activity	Acceptable Neil Frequency
M.1	Indicating Devices	Test	18 Months
M.2	Annunciators	Test	18 Months
M.3	Control Panels	Test	18 Months
M.4	Supervisory Devices	Test	18 Months

A is a summary of maintenance, test, and inspections for the aforementioned category M components are listed below:
M.1. At least every 18 months' fire alarm systems components monitored for alarm, supervisory, and trouble signals such as: fuses, interfaced equipment, lamp / LEDs, primary (main) power supply, and need to be tested to verify the following:
· At a minimum, control equipment needs to be tested to verify correct receipt of alarm, supervisory, and trouble signals (inputs), operation of evacuation signals and auxiliary functions (outputs), circuit supervision including detection of open circuits and ground faults, and power supply supervision for detection of loss of ac power and disconnection of secondary batteries.
· The rating and supervision fuses need to be verified.
· Integrity of single or multiple circuits providing interface between two or more control panels need to be verified. Interfaced equipment connections need to be tested by operating or simulating operation of the equipment being supervised. Signals required to be transmitted need to be verified at the control panel. Lamps / LEDs need to be illuminated.
· All secondary (standby) power needs to be disconnected and tested under maximum load, including all alarm appliances requiring simultaneous operation. All secondary (standby) power needs to be reconnected at end of test. For redundant power supplies, each needs to be tested separately.
· The correct operation and identification of annunciators needs to be verified. If provided, the correct operation of annunciators under a fault condition needs to be verified.
· Supervising Station Fire Alarm Systems - Transmission Equipment testing NFPA 72 Table

7.2.2 item 10 was removed due to duplication.
· It is recognized that this testing may be performed in conjunction with other testing.

M.2. At least every 18 months, the correct operation and identification of annunciators is to be verified. If provided, the correct operation of annunciators under a fault condition will also be verified. It is recognized that this testing may be performed in conjunction with other testing.

M.3 The control panel testing is functionally performed during the initiating device testing.

M.4 At least every 18 months, room temperature switches need to be operated. Receipt of signal to indicate the decrease in room temperature to 40°F (4.4°C) and its restoration to above 40°F (4.4°C) needs to be verified.

Testing requirements of NFPA 72 Table 7.2.2 item h, which are duplicated in other sections of the appendix, were not restated. These include valve supervisory, low air pressure, tank level, water temperature, and water flow devices.

N. Automatic Fire Detectors
Below in Table 21Automatic Fire Detectors, Maintenance, Test, and Inspections Testing Requirements based on NFPA 72 (2002) Chapter 10 have been provided.

Table 21 Automatic Fire Detectors, Maintenance, Test, and Inspections Testing Requirements

Category	Component	Activity	Acceptable Neil Frequency
N.5	Smoke	Test	18 months
N.6	Smoke	Test-Sensitivity	Per Code of Record At Construction

A summary of maintenance, test, and inspections for the aforementioned category N components are listed below:
N.5. Ionization and photoelectric detectors need to be tested in place to ensure smoke entry into the sensing chamber and an alarm response. Testing with smoke or listed aerosol approved by the manufacturer will be permitted as ACCEPTABLE test methods. Other methods approved by the manufacturer that ensure smoke entry into the sensing chamber will be permitted.
Projected beam detectors need to be tested by introducing smoke, other aerosol, or an optical filter into the beam path.

Tests of Smoke detectors with control output functions need to verified that the control capability remain operable even if all of the initiating devices connected to the same initiating device circuit or signaling line circuit are in an alarm state.
Air sampling detectors are tested per manufacturer’s recommended test methods, detector alarm response will be verified through the end sampling port on each pipe run; airflow through all other ports need to be verified as well.

N.6.When required by stations code of record, any of the following tests may be performed to ensure that each smoke detector is within its listed and marked sensitivity range:
· Calibrated test method
· Manufacturer’s calibrated sensitivity test instrument
· Listed control equipment arranged for the purpose
· Smoke detector/control unit arrangement whereby the detector causes a signal at the control unit when its sensitivity is outside its listed sensitivity range
· Other calibrated sensitivity test method ACCEPTED by NEIL

O. Valves

Below in Table 22 Pump House Valves Maintenance, Test, and Inspections Testing Requirements based on NFPA 25 (2002) Chapter 8 and Chapter 12; NFPA 72 (2002) Chapter 10 have been provided.

Table 22 Pump House Valves Maintenance, Test, and Inspections Testing Requirements

Category	Component	Activity	Acceptable Neil Frequency
O.1	Valves - Fire Pump	Test	Monthly
O.2	Control Valves - No Supervision/ Sealed	Inspect	Monthly
O.3	Control Valves - Electrically Supervised/Locked	Inspect	Quarterly
O.4	Control Valves - OS&Y	Maintain	5 years
O.6	Control Valves	Operate	Annual
O.7	Valve Tamper Devices	Test	18 Months

A summary of maintenance, test, and inspections for the aforementioned category O components are listed below:

NOTE: Where valves are the primary isolation of a water based fire suppression system, such that the valve isolates only one suppression system and is located directly adjacent to the suppression system operational components, that valve can be cycled and maintained at the same frequency as the associated system's functional test.

O.1. Fire pump valves such as the suction and discharge, bypass and other valves that can affect pump operability need to be verified to be fully open on a monthly basis.

O.2. Inspection of valves without supervision need to be verify, on a monthly basis, that the valves are in the following condition:

· In the normal open or closed position
· Properly sealed
· Accessible
· Provided with appropriate wrenches
· Free from external leaks
· Provided with appropriate identification

O.3. Inspection of valves with supervision need to be verify, on a quarterly basis, that the valves are in the following condition:

· In the normal open or closed position
· Locked, or supervised
· Accessible
· Provided with appropriate wrenches
· Free from external leaks
· Provided with appropriate identification

O.4. The operating stems of outside screw and yoke valves need to be lubricated when the valve operation required by O.5 indicates lubrication is required such that the frequency does not exceed five years. The valve then will need to be completely closed and reopened to test its operation and to distribute the lubricant.

O.5. Annually each control valve needs to be operated through its full range and returned to its normal position. Post indicator valves need to be opened until spring or torsion is felt in the rod,

indicating that the rod has not become detached from the valve. Post indicating and outside screw and yoke valves may be backed a one-quarter turn from the fully open position to prevent jamming. This test will normally be conducted every time the valve is closed.
O.6 Control Valve Switch needs to be operated and signal receipt verified to be within the first two revolutions of the hand wheel or within one-fifth of the travel distance, or per the manufacturer's specifications.

P. Portable Extinguishers

Below in Table 23 Portable Extinguishers Maintenance, Test, and Inspections
Testing Requirements based on NFPA 10 (2002) Chapter 6 and Chapter 7 have been provided.

Table 23 Portable Extinguishers Maintenance, Test, and Inspection Requirements

Category	Component	Activity	Acceptable Neil Frequency
P.1	Portable Extinguisher	Inspect	Quarterly
P.2	Portable Extinguisher	Maintain	Annual

CAUTION: The NEIL ACCEPTABLE frequency has been determined for insurance purposes only. The Member must review the effect on Local, State, Federal, and other Jurisdictional requirements.

A summary of maintenance, test, and inspections for the aforementioned category P components are listed below:

P.1. Fire extinguishers need to be inspected to ensure they are available and will operate. It is intended to give reasonable assurance that a fire extinguisher is fully charged and operable. This is done by verifying that it is in its designated place, that it has not been actuated or tampered with, and that there is no obvious or physical damage or condition to prevent its operation. Personnel making inspections need to keep records of all fire extinguishers inspected, including those found to require corrective action.

The inspections frequency needs to be based on the need of the area in which fire extinguishers are located. The NEIL ACCEPTABLE inspection frequency is a minimum. An inspection may need to be more frequent if any of the following conditions exist:
· High frequency of fires in the past
· Severe hazards
· Susceptibility to tampering, vandalism, or malicious mischief
· Possibility of, or experience with, theft of fire extinguishers
· Locations that make fire extinguishers susceptible to mechanical injury
· Possibility of visible or physical obstructions
· Exposure to abnormal temperatures or corrosive atmospheres
· Characteristics of fire extinguishers, such as susceptibility to leakage

P.2. Fire extinguishers need to be subjected to maintenance at intervals of not more than 1 year, at the time of hydrostatic test, and when specifically indicated by an inspection. Maintenance is a thorough examination of the fire extinguisher. It is intended to give maximum assurance that a fire extinguisher will operate effectively and safely. It includes a thorough examination and any necessary repair or replacement. It will normally reveal if hydrostatic testing or internal maintenance is required.
The maintenance needs to include a thorough examination of the three basic elements of a fire extinguisher:

· Mechanical parts
· Extinguishing agent
· Expelling means

Prescriptive Analysis Conclusion:
Building X meets the occupant protection, structural integrity, and system effectiveness objectives listed in LSC sections 4.2.1 thru 4.2.3 and satisfies the prescriptive requirements set forth in the 2009 LSC section 4.4.2.2 Prescriptive-based designs meeting the requirements of Chapters 1 through 3, Sections 4.5 through 4.8, and Chapters 6 through 43 of this *Code* shall be deemed to satisfy the [Ref1].

Although the fire protection detection and suppression systems meets the prescriptive requirements in the 2009 LSC, a performance based analysis was also done since Building X is a support structure for a nuclear plan that falls under NFPA 805 regulatory basis. The performance based analysis for the fire protection system is presented below in the next section 9.0 Performance-Based Analysis.

9.0 Performance-Based Analysis
In general, a performance based fire protection design must meet the objectives specified in NFPA 101 section 4.2 for each design fire scenario, assumption, and design specifications, the performance criteria in 5.2.2 is met. 5.2.2* Performance Criterion. Any occupant who is not intimate with ignition shall not get caught in flashover of a fire. The following performance based analysis was performed for the three fire scenarios listed below in order to validate the performance based design objectives set forth in NFPA 101 section 4.2.1, 4.2.2, and 4.2.3.
Ultimately if the actual safe egress time is greater than the required safe egress time (ASET>RSET) that the performance based design objectives have been met.
The performance based design is a great undertaking and investment since the performance based design must be prepared by a registered design professional in accordance with NFPA 101section 5.1.3. In addition, in accordance with NFPA 101 section 5.1.4 the authority having jurisdiction shall be permitted to require an approved, independent third party to review the proposed design and provide an Independent Review of the design [Ref1].

In accordance with NFPA 101 section 5.1.6* the authority having jurisdiction shall make the final determination as to whether the performance objectives have been met.

In summary performance-based approaches lends itself towards more formulated results based on calculated inputs (i.e. defined design specifications and fire scenarios) opposed to prescriptive requirements where the primary objective is to ensure life safety is predicated on defense in depth and not solely dependent on one feature. Obviously both a successful acceptance testing and preventative maintenance program to ensure the system will perform as designed before it’s turned over and continues to function within specifications is essential. In addition, building modifications and changes in occupancy loads and or activities performed in rooms for which the system was designed must be evaluated to ensure system modifications are not warranted.

The scope of the analysis for the entire building was limited to the hand calculated required safe egress time (RSET)analysis in Appendix B compared to the Actual Safe Egress Time (ASET) and the tenability analysis in section 10.2 below.
In addition, section 10.3 depicts an analysis performed using one fire scenario that met the performance criteria of NFPA 101 section 5.2.2.

9.1 Factors Affecting Tenability Performance
Building X is 75,674 gross sq. ft. and has a general occupancy classification of business and assembly (A-1/A-3). However, in accordance with IBC 2006 sec 508.3, each portion of the building shall be individually classified in accordance with section 302.1. Where a building contains more than one occupancy group, the building or portion thereof shall comply with section 508.3.1, 508.3.3 or a combination of these sections [Ref:4].

There are no hazardous materials in use at this facility thus there separate hoods or ventilation supplied to expel toxicants. Any and all building design and operational characteristics and behaviors that impact the egress times have been included as part of the performance-based evaluation to ensure egress times are compatible with tenable condition times. Some factors to consider are documented below:

Summary of the primary behavioral factors that influence pre-movement times in building evacuations are affected:

Human Behavior Elements of Egress:

It should be noted that an individual's behavior in a fire is affected by certain variables of the building in which the fire occurs and by the appearance of the fire at the time of detection. In general, the occupants' response will vary if they smell smoke rather than see flames or dark, acrid smoke completely obscuring a corridor. Variables of the fire protection provided for the building may also be critical to the individual's perception of the threat involved. In addition, awareness and types of cues and alarms play an important role in an occupant's behavior to a fire event. This theory has been validated by Ramachandran who theorized the development of "informative fire warning systems," which use a graphic display with a computer-generated message and a high-pitched alerting tone, has reduced the observed delay times in the initiation of practice evacuations. In addition, it is sometimes it is sometimes difficult to get the occupants of a building to evacuate because of social inhibition and diffused responsibility.

Pre-movement times are synonymous with delay times, where initial response time, or time to start, can last from a few seconds to several minutes or more. It is important to remember that during this period of delay, people might be simply ignoring available cues, or they might be engaged in pre-evacuation activities. Delay time includes time to notification, reaction time, and pre-evacuation activity time [Ref: 2].

Summary of factors, which are related to the characteristics of the occupants that can result in variations in delay time:

1. Effectiveness of different cues, (i.e. types of alarms, audible alarms verses voice instruction alarm)

2. Effectiveness or training (level of detailed training provided to occupants on equipment use, exits. exit paths, protected paths of travel high combustible location, assembly areas.

3. Time of day, weather, and so on; alarm devices use different sounds may be confused or misinterpreted with similar sounds produced in thunder storms or burglar alarms which result among in building occupants being confused or not reacting to the actual fire alarm.

4. The time of day and weather can adversely affect pre-movement delays. People may be reluctant to leave a building during a storm, in cold weather, or during the night.

5. People with hearing impairments may not hear or interpret the sound of an alarm as quickly as people without impairments. People with mobility impairments may be slower to prepare themselves to evacuate or move to another location in the building. People who are engrossed in an activity may be too preoccupied to hear an alarm or warnings from other occupants, and then may be reluctant to leave what they are doing to take refuge.

6. Prevalence, type, and mobility of disabled people and capability of disabled people to move horizontally or on an incline. The capability of disabled people to negotiate doors and capability of disabled people to read and locate exit signs

7. Building characteristics and type of occupancy (i.e. hotel residents may stop to pack their bags prior to pursuing an exit.

8. The inability of handicapped people to properly read exit signs for paths of egress

9. Level of information provided to occupant during time of event will have a direct impact on calmness and egress efficiency of the crowd.

10. The smell or sight of smoke or flames will result in possible panic

Summary of design and operational features for Building X that reduce pre-movement and egress time:

1. Incipient detection has been installed in rooms with large extensive amounts of wiring to provide operations with early warning prior to inception of fire.
2. Training has demonstrated a reduction in delay times. Trained building occupants can be expected to know where the closest exits are, recognize the alarm signal and know required actions to take, that will ultimately result in shorter delay times.
3. Staff that is properly trained and capable of directing occupants in health care or mental facilities has been known to reduce delay times.
4. Unannounced fire drills are held quarterly
5. Development of pre-fire plans, occupants and fire department are briefed on the pre-fire plans and locations of safety and firefighting equipment within the zone.
6. Designers have designed doors to open outward towards the exit paths. In addition, designers have considered the nature and position of support systems for handicapped people such as handrails, positioning of doors in escape routes and designed ramps since these will influence the progress and the flight behaviors of some disabled occupants.
7. Designers incorporated consideration for handicap occupant's door leaf widths, elevator locations, height positions of operation buttons within in addition the elevator should be at height that can be reached by wheelchair bound individuals.
8. Designers should use LED signs which have proven to be the most visible and legible by the disabled persons with and without vision disabilities.
9. Provide proper ventilation and protection of vertical shafts that will be used for egress to negate it being filled with smoke during a fire.
10. Designers should strive for simplicity in all access and movement routes; which lessens the need for directional graphics and ushers.
11. Capacity-handling channels should be designed to be continuous walking surfaces; such as ramps stairs are satisfactory to shorten channels not subject to heavy pedestrian loads.
12. Don't allow public access to building unless they have had a safety brief and are accompanied by an escort.

Characteristics and behaviors that may increase egress times:
Visitors that are in the building are untrained in respect regular building occupants and have not been exposed to fire drills which will result in possible delays.

9.2 Tenability Performance Criteria

Section LSC 5.2.2 states any occupant who is not intimate with ignition shall not be exposed to instantaneous or cumulative untenable conditions. This report follows Method 1 of four methods provided by the LSC which defines performance criteria that ensures occupants are not incapacitated by fire effects.

9.2.1 Visibility Levels

The optical density of smoke during a given fire scenario has direct impact in the speed of egress, exits selected. The impacts that smoke have on occupants depends upon the concentration of smoke and the level it irritates the occupants. There was a noticeable decrease in walking speed when the smoke density was at an optical density of 0.5/m (extinction coefficient 1.15) walking speed decreased from approximately1.2 m/s (no smoke) to 0.3 m/s. Therefore, the following tenable range for visibility is recommended per the following calculation at S= 8 for eliminated

S= 8/1.5 =5.3 m

Therefore, the Tenable visibility range is > 5.3 m and must be maintained above eye level of 1.8 m or 6 ft. [Ref: NFPA HB and NFPA 101]

9.2.2 Exposure to Toxic Gases

For the majority of toxic products in a fire atmosphere a given toxic endpoint such as incapacitation or death occurs when the victim has inhaled a particular *Ct* product dose of toxicant. The point in time when a victim has inhaled a toxic dose of carbon monoxide, hydrogen cyanide, carbon dioxide, hydrogen chloride, hydrogen bromide, and anoxia or incapacitation level can be obtained by integrating the area under the fire profile curve for the toxicant under consideration when the integral is the toxic dose.

The victim can be assumed to have received a dose capable of producing that toxic effect at the prescribed exposure time calculated in the Fractional Effective Dose FED analysis. FED is a practical method used in calculating the time for a victim to have received a toxic dose; the equation for FED is as follows [Ref: 5]:

$$\text{FED} = \frac{\text{Dose Received at time t (ct)}}{\text{Effective Ct Dose to cause incapacitation or death}}$$

In practice, however, it may be necessary to predict what will happen to a subject exposed to a higher concentration for a shorter period of time, or a lower concentration for longer time. Although this can be done by carrying out more *LC*50 experiments using different exposure durations, as an approximation toxicologist often resort to Haber's rule, which states that the toxicity depends upon the dose accumulated, and that the product of time and concentration is a constant,20 so that

W=C Xt (1)

C= concentration

T= exposure time

In particular, some volatile substances (such as CO) are both taken up and excreted via the lungs. In this case the rate of uptake depends upon the difference between the concentration inhaled and that in the body, giving an exponential uptake so that:

$W= C\ (1 - e^{-tk})$ (3)

which is the basis for the Coburn-Forster-Kane (CFK) equation 22, 23 describing the uptake of CO in humans. This relationship approaches the linear Haber's rule (Equation 1) when the concentration, *C,* in the atmosphere is high with respect to the concentration in the body required to cause incapacitation or death (Figure 2-6.4), and for short exposures to high CO concentrations, uptake is approximately linear [Ref:8].

In experiments animals (primates) became unconscious when exposed to approximately 27,000 ppm/min of CO at concentrations between 1000 and 8000 ppm. These experiments validated the use of linear models for CO uptake without serious error. Some toxic effects, however, are not dependent upon a dose acquired over a period of time, but are concentration related. Thus the irritant effects of smoke products on the eyes and upper respiratory tract (sensory irritation) occur immediately upon exposure, with the severity depending upon the exposure concentration [Ref: 9].

For substances obeying Haber's rule the denominator of the equation is a constant for any particular toxic effect. For substances deviating from Haber's rule the denominator for each time segment during the fire is the *Ct* product dose at which incapacitation or death would occur at the concentration during that time segment. The denominator is presented in the form of equations giving the required *Ct* product doses predicted for man, which have been derived for each toxic gas. Special cases of the fractional effective dose are referred to as the *fractional incapacitating dose* (FID) and the *fractional lethal dose* (FLD). For sensory irritation—a toxic effect which depends upon the immediate concentration of an irritant to which a subject is exposed, rather than the dose—a concept of *fractional irritant concentration* (FIC) has been developed, where

$$FIC = \frac{\text{concentration of irritant to which subject is exposed at time } (t)}{\text{Concentration of irritant required to cause impairment of escape efficiency}} \quad (5)$$

To understand the effects of CO exposure on fire victims and to predict the likely consequences of a particular exposure, it is essential to know a number of features of CO intoxication; to some extent these apply to an evaluation of the toxicity of any fire product. Thus it is necessary to determine the following:

1. Determine which types of toxic effects occur at different dose levels.
2. Determine the concentration/time relationships of these toxic effects, whether they occur immediately Or sometime after exposure, and whether the effects of a short high concentration exposure are the same as those of a longer, low concentration, exposure.
3. Quantify the parameters that determine the rate of uptake and removal of CO from the body [Ref: 8].

Since CO is both inhaled and excreted via the lungs, the rate of uptake depends upon the difference between the CO concentration in the blood, *W,* and that in the inhaled air, *C,* and is an exponential function described by the general equation (Equation 3):

$$W = C\,(1 - e^{-tk}) \quad (3)$$

where t is the time exposed and k is a constant determined by a number of factors, so that uptake is rapid initially, but gradually levels off as uptake and removal from the blood reach equilibrium. This relationship is also described fully by the Coburn-Forster-Kane (CFK) equation 22, 23 which takes into account a whole range of variables, including RMV, body size, exposure duration, and parameters related to lung and blood physiology [Ref:8].

%COHb C (3.317 - 10>5)(ppm CO)1.036(RMV)(t) (6)

Where ppm CO =CO concentration (ppm)
RMV= volume of air breathed (L/min)
t = exposure time (min)

An example tenability analysis is provided below to determine the time for incapacitation with an assumed steady-state CO concentration of 2,500 ppm and a 5% CO2 concentration and a linear increasing rate of CO of 1000 ppm/min and a CO2 concentration increasing at 1% per minute where (FICN and FLDIRR) are ignored in Purser equation (21) [Ref.8].
The following assumptions were made for this example:

1. Assume that CO and HCN are directly additive (1:1) on a fractional dose basis (the evidence suggests that they are additive, but that the additive interaction may actually be less than unity).
2. Assume that the rates of uptake of CO and HCN and their fractional doses are increased in proportion to any increase in ventilation (RMV) caused by carbon dioxide.
3. Assume that the fractional doses of CO and HCN, adapted for carbon dioxide, are additive with the fractional dose of low-oxygen hypoxia.
4. Assume that asphyxia by carbon dioxide is independent of that induced by CO, HCN, and hypoxia.
5. Assume that irritancy is independent of asphyxia, but that uptake of irritants is increased by carbon dioxide

Fundamental Equations:

$$FI_{co} = \frac{K(\text{ppm } CO^{1.036})\,(t)}{D} \qquad (7)$$

where

FI_{co}= fraction of incapacitating dose
t = exposure time (min)
K = 8.2925 10–4 for 25 L/min RMV (light activity)
D =COHb concentration at incapacitation (30 percent for light activity)

$$F_{IN} = [(F_{ICO} + F_{ICN} + FLD_{irr})\, X VCO_2 + FED_{IO}] \text{ or } F_{ICO2} \qquad (21)$$

Where

F_{IN} =fraction of an incapacitating dose of all asphyxiate gases

F_{ICO}= fraction of an incapacitating dose of CO

F_{ICN}= fraction of an incapacitating dose of HCN (and nitrides, corrected for NO2)

FLD_{irr} =fraction of an irritant dose contributing to hypoxia (This term represents a correction for the effects of irritants on lung function and is developed in the section on irritants. This term may be omitted if the effects of asphyxiate gases only are under consideration)

VCO_2 =multiplication factor for CO2-induced hyperventilation

FED_{IO} = fraction of an incapacitating dose of low-oxygen hypoxia

FED_{ICO2}=fraction of an incapacitating dose of CO2

Where each individual term in the FED equation is itself the result of the following equations, which give the FED for incapacitation for each gas and the multiplication factor for CO2, where t is the exposure time at a particular concentration in minutes. The FED acquired over each period of time during the fire are summed until the total FED_{IN} reaches unity, at which point incapacitation (loss of consciousness) is predicted. In order to allow for differences in sensitivity and to protect susceptible human Subpopulations a factor of 0.1 FED should allow for safe escape of nearly all exposed individuals. Death is predicted at approximately two to three times the incapacitating dose for a 1-minute exposure to each gas at a concentration

$$F_{ICO} = \frac{8.2925 \text{ X}10^{-4} \text{ X ppm } CO^{1.036}}{30}$$

$$F'_{ICN} = \frac{(\exp([CN]/43))}{220} \qquad (11)$$

Corrected for the presence of other nitrides besides HCN and for the protective effect of NO2. CN can be calculated as [CN] C [HCN] = [total organic nitrides- [NO2]

$$VCO_2 C \exp \frac{[CO_2]}{5} \qquad (18)$$

$$FLD_{irr} = FLD_{HCl} + FLD_{HBr} + FLD_{HF} + FLD_{SO2} + FLD_{NO2} + FLD_{CH2CHO} + FLD_{HCHO} + \Sigma FLD_x \qquad (22)$$

where $\Sigma FLD_x = FLD_s$ for any other irritants present

$$F'_{IO} = \frac{1}{\exp[8.13\ \ 0.54(20.9 - \%O_2)]}$$

$F'_{IcO2} = \frac{1}{\exp[6.1623 - 0.5189 - \%O_2)]}$

Calculated CO2 limits:

Figure 2-6.19 in the [Ref: 8] shows an expanded detail of asphyxiant gas profiles during the first 10 minutes of the single armchair room burn that is presented in more detail in Figure 2-6.15 [Ref: 8]. The histograms show the average concentrations of each gas at minute intervals during the first 6 min of the fire]. The HCN concentration was not measured in this fire, but it is likely to have been present as a major toxic product. Possible HCN concentrations have therefore been suggested for inclusion in the model and are shown in a histogram in the handbook. Applying the expressions for the fractional incapacitating dose of each gas to the data in Table 1-1, the total fractional dose of all asphyxiant gases for each minute during the fire (*FIN*) has been calculated according to Equation 21, and summed for each successive minute during the fire, as shown in Table 1-2.

Table 24 Problem Parameters

Time (min)	1	2	3	4	5	6
CO ppm	0	0	500	2000	3500	6000
HCN ppm	0	0	0	75	125	174
CO_2%	0	0	1.5	3.5	6	8
O_2%	20.9	20.9	19	17.5	15	12

Conclusion of Incapacitation Results:

Incapacitation (loss of consciousness) is predicted at 5 min when the fractional incapacitating dose exceeds unity (*FIN* C 1.2). The steady state results shown as estimated a 4 minute incapacitation time assuming a steady-state CO concentration of 2,500 ppm and a 5% CO2 concentration occurred. An estimated time for incapacitation assuming a linear increasing rate of CO of 1000 ppm/min and a CO2 concentration increasing at 1% per minute was estimated to be between 5 and 6 minutes as shown respectively in Table 1-2 and 1-3 below.

Table 25Steady State Results given CO concentration of 2,500 ppm and a 5% CO2 concentration

		F'(I)	V (CO2)	
CO ppm	2500	0.092		
CO2 %	5	0.028	2.718	Note significance of VCO2
O2 %	.855	0.001		
	F'(IN)	0.249	1/min	[F'(Ico) x V (CO2) + F'(Io2)]
	t(IN)	4.008)	min	1/F'(IN)

Table 26 Results for transient with linear increasing rate given CO of 1000 ppm/min and a CO2 concentration increasing at 1% per minute

Time(min)	1	2	3	4	5	6	7	8	9	10	11
Co ppm	500	1500	2500	3500	4500	5500	6500	7500	8500	9500	10500
CO2 %	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5
O2%	20.796	20.587	20.378	20.169	19.960	19.751	19.542	19.333	19.124	18.915	18.706
F'(Ico)	0.017	0.054	0.092	0.130	0.168	0.207	0.246	0.286	0.325	0.365	0.405
V((CO2)	1.105	1.350	1.649	2.014	2.460	3.004	3.669	4.482	5.474	6.686	8.166
F'(Ico)xV(CO2)	0.019	0.073	0.151	0.261	0.414	0.623	0.904	1.281	1.781	2.441	3.308
F'(Io2)	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
TotalF'(IN)	0.019	0.073	0.151	0.262	0.415	0.623	0.905	1.282	1.782	2.442	3.309
Running total	0.019	0.093	0.244	0.506	0.920	1.544	2.449	3.730	5.512	7.955	11.263

Based on the tenability analysis presented in section 7.2 An estimated time for incapacitation assuming a linear increasing rate of CO of 1000 ppm/min and a CO2 concentration increasing at 1% per minute was estimated to be between 5 and 6 minutes as shown respectively in Table 1-2 and 1-3 above.

Given that the tenability parameter of exposure to CO for 6 minutes has the more stringent time constraint of 6 minutes it is viewed as the determining factor for ASET.

ASET =6 minutes (at max)

9.2.3 Exposure to Heat

In addition to smoke toxicity convective and radiant heat analysis must be performed to ensure the thermal effects do not act as barriers for egressing occupants. There is a possibility for an active occupant to become incapacitated when the humidity is high. Death can even occur in situations where the occupant experiences extreme hyperthermia for an extended time, which is dependent upon heat flux to which the occupant is exposed. Simple hyperthermia involves prolonged exposure for approximately 15 minutes or more to heated environments at temperatures at approximately 120°C for dry air or 80°C for saturated air, the main effect is a gradual increase in the body core temperature. Increases above normal body core temperature of 37°C are considered harmless, however core temperature increases in excess of 39°C can be considered to be lethal [Ref: 9].

Therefore, a tenable temperate range of men working for 25 min > 60 °C see figure Fig. 2-6.27 [Ref: 9].

9.2.4 Tenability Conclusion for Entire Building Occupants

A detailed hand calculation in Appendix B provided a RSET of 6.4 minutes for the total building population of 970 occupants that would have to egress through the subject 7 exits at any given time
A simpler linear formula was used to calculate RSET for fire scenario 1.
Available safe egress time (ASET) is defined by occupant tenability criteria and determination through modeling of the time to exceed thresholds for these criteria.
$ASET = \min(t_{vis}\ , t_{co}, t_T)$= 5.3 and 1.8 meters or 6 ft. in height, 6 minutes max, 60°C

Smoke Control System Performance:

In this case a prescriptive based standard from section 909.4 states all active portions of a smoke control system shall be capable of continued operation for not less than 20 minutes after a fire event or 1.5 times the calculated egress time.
1.5 times the calculated egress time of 6.4 minutes = 9.6 minutes or 20 minutes

The smoke control system design is acceptable when ASET >RSET (including factor of safety).

The RSET or maximum predicted evacuation time of 970 occupants that would have to egress through the subject 7 exits at any given time was target sample for evaluation which took over 6 minutes and 40 seconds as shown in Table 9 of Appendix B.
RSET =6 minutes and 40 seconds
Therefore, ASET<RSET

Based on the hand calculations in Appendix B since the minimal required egress time for a total allowable capacity of 970 occupants is 6 minutes and 40 seconds which would result in a large number of occupants being exposed to cumulative untenable conditions in the form of toxicants in Building X. However, Building X never is fully occupied to the maximum allowable capacity of 970 occupants at any given time. Thus the RSET of 6.4 minutes would not be challenged.

9.3 Performance Based Evaluation of RSET Verses ASET
Again given that Available Safe Egress Time (ASET) is defined as the available safe egress time before the fire area is exposed to a tenability parameter that can incapacitate the occupants.
The Required Safe Egress Time (RSET) is the required safe egress time it takes the occupants to egress the fire area during a fire event.

Therefore, the fire scenarios that were used in this performance based fire protection analysis to determine if ASET>RSET were as follows.

I. <u>Performance Based Fire Scenario Fire Scenario I</u>
The following fire scenario was selected in accordance with NFPA 101 section 5.5.3.1* which requires that a design fire that is typical for the type of occupancy and activities being performed in an area and reflects the types of fuel sources and ventilation be used as the type of design fire selected.

- In this scenario an upholstered chair catches on fire in the large furnished meeting room area with one exit where the door is closed see (Figure 3-L for furniture location and spacing) on the northeast side of the building where 18 occupants are attending a meeting. They can exit the meeting room and through one of the two exits out of the larger office area which contains 89 occupants. The dimensions for the meeting room which catches on fire and has been evaluated below the CFAST model to determine ASET are 52’ X 42’ with 8’ ceilings.

Note; Figure 15 also depicts the paths of egress of the main office area which is adjacent to the executive meeting room which initially catches on fire.

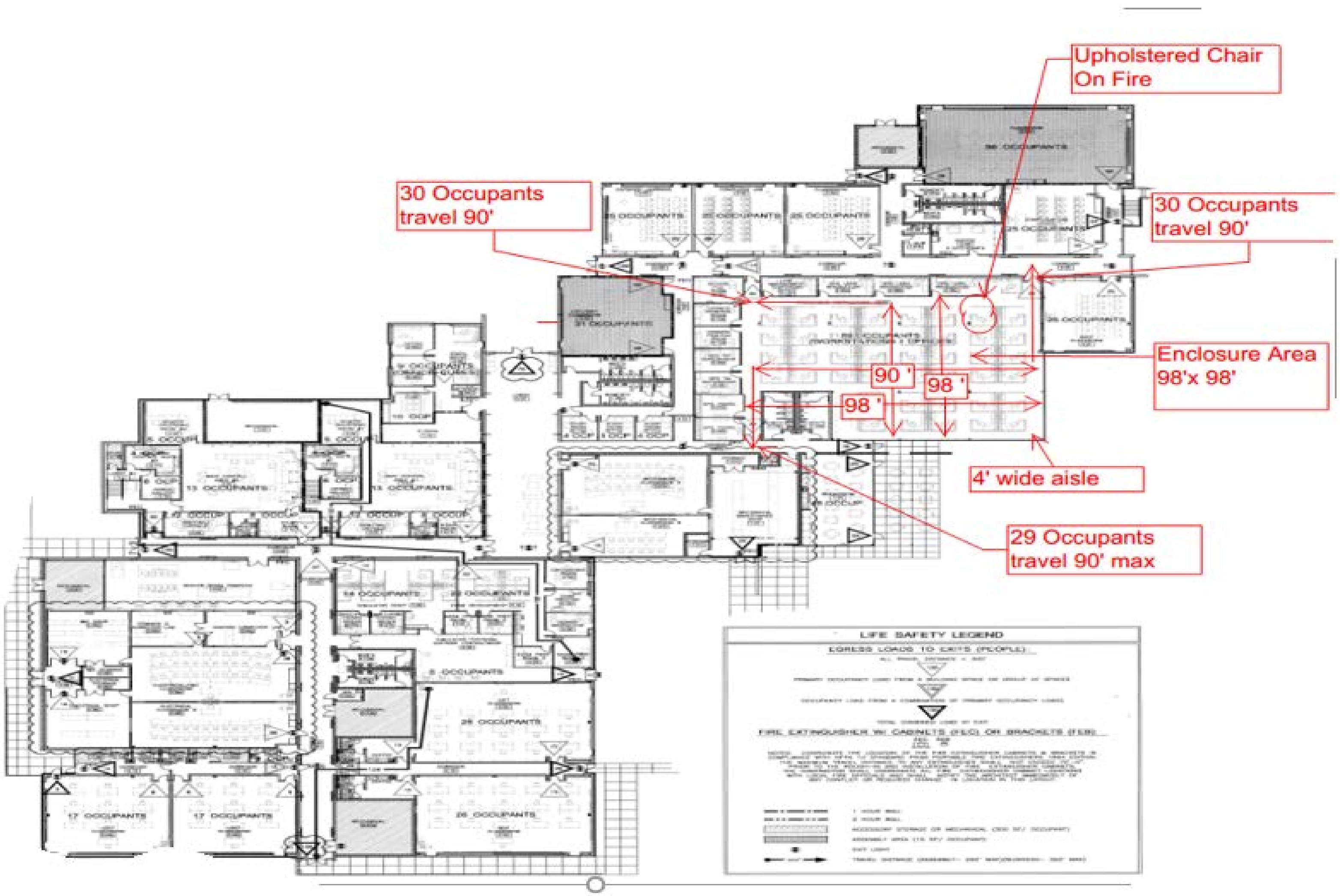


Figure 15 Scenario 1 Large Office Egress Path and Exit Discharge

For this fire scenario the following properties and parameters were assumed:

9.4 Fire Properties:

The dimensions for the executive meeting room which catches on fire and has been evaluated below with the hand calculation and in the CFAST model to determine ASET are 52’ X 42’ with 8’ ceilings.

Properties for a combination of the components for which an upholstered chair is built with were used below:

1) Fuel Types in Fire Area: Upholstered Chair
2) Design Fire Peak HRR: 2000 KW See Figure 3-1.1.52 [Ref: 9]
3) CO: 0.028 kg per kg Table 3.5[Ref: 9]
4) Soot Yield 0.10 kg per kg Table 3.5[Ref: 9]
5) Heat of Combustion: 20,900 KJ/KG Table 3-4.16 [Ref: 9] used in CFAST
6) Radiative Fraction:0.49 Table 3-4.16 [Ref: 9] used in CFAST
7) Fire Growth: “t-squared” curve to a maximum value of 464 kW in 12 min and remains steady for 8 additional min. See page G5 [Ref: NUREG/CR-6850 (EPRI 1011989)]
8) Enclosure dimensions:
9) Type of detection: automatic sprinklers
10) Type of suppression: automatic sprinklers
11) Ventilation: Well ventilated/ Ventilation rate 1.42 m3 /s (3,000 cfm) see page B-10[Ref: NUREG 1934 EPRI 1023259]

9.5 Available Safe Egress Time (ASET)

The office area where the upholstered chair originated was modeled using CFAST.
Note that it is assumed that all office doors surrounding the subject large office area are assumed to be closed in accordance with the safety procedure for the building.
The design fire is an upholstered chair that starts in the north east corner of the large office area, commonly referred to as type F21 in the in the SFPE HB [Ref 9], with a peak heat release rate of 2000kW and a medium fire growth rate. To simulate the somewhat sooty smoke that is anticipated to be produced by combustion of the wooden chair frame with polyurethane upholstery foam and synthetic polyester fabrics used in this type of furniture, a soot yield of 0.10 kg per kg of fuel is used in the CFAST fire model. This number is a composite of the soot yields of the three major components of the furniture. An approximate carbon monoxide yields of a well ventilated fire, which a single upholstered chair in a relatively large and open room might provide, a CO yield of 0.028 kg per kg of fuel is similarly used [Ref:9].
A CFAST Model was running for 3600 seconds where the maximum temperature of the burning chair was reached a maximum temperature of 114º Celsius. Thus it is estimated that the first sprinkler head will actuate at that temperature and prevent the spread of fire to other fuel sources in the adjacent large office area.
The tenability limits were calculated using CFAST fire modeling and are depicted in the analysis and graphs in Figures 17,18, and 19 below.

Figure 18 below depicts time at which Visibility Level reached 6 feet or 1.8 m was 520 seconds 8.6 minutes as shown in the graph produced from the CFAST Smoke View Model.

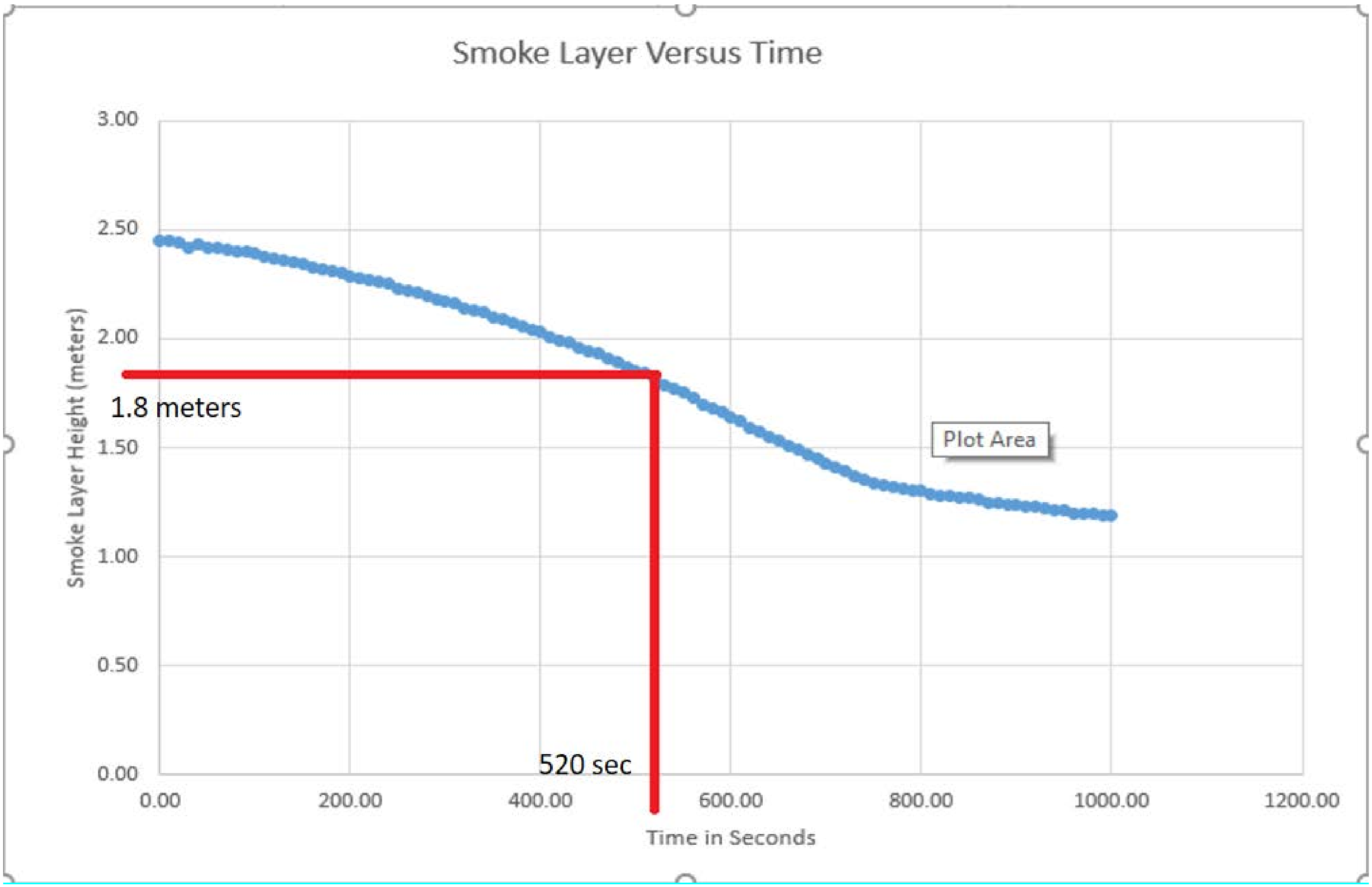


Figure 16 Soot Yield Levels Verses Time Visibility for Large Meeting Room

Figure 17 below depicts that although the smoke layer temperature exceeded 60°C at 380 seconds a Tenability Limit is not considered as being reached since the smoke layer is still above 1.8 meters since it is above the occupant's heads.

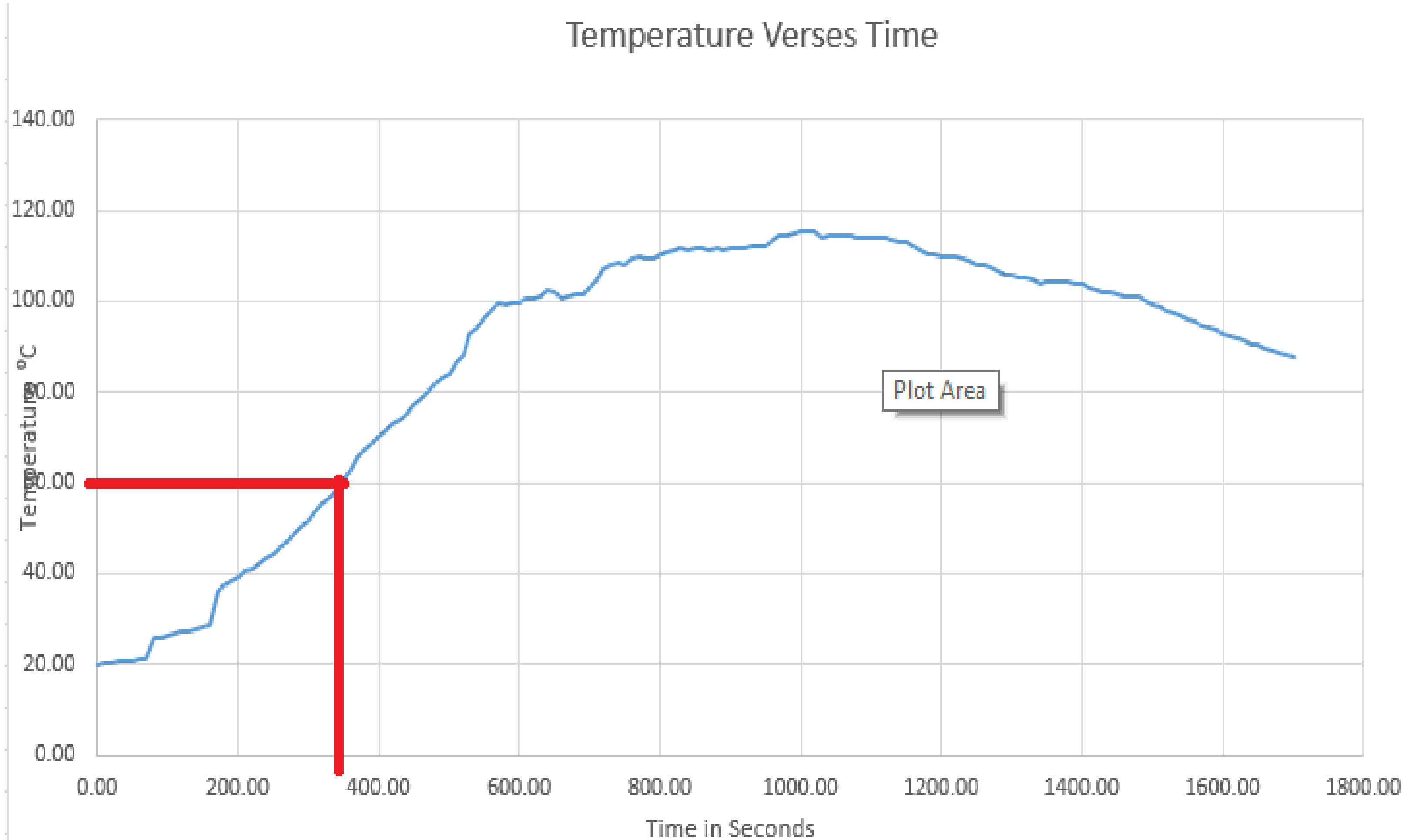


Figure 17 Tenability Limit for Temperature Verses Time for Large Meeting Room

Tenability parameter of exposure to CO2 has no impact since Figure 18 below depicts that not enough CO2 is being added to decrease the amount of O2 to 12% or less where there would be an impact to breathing. An Additional 10 % CO2 would only decrease the O2 levels to 19%.

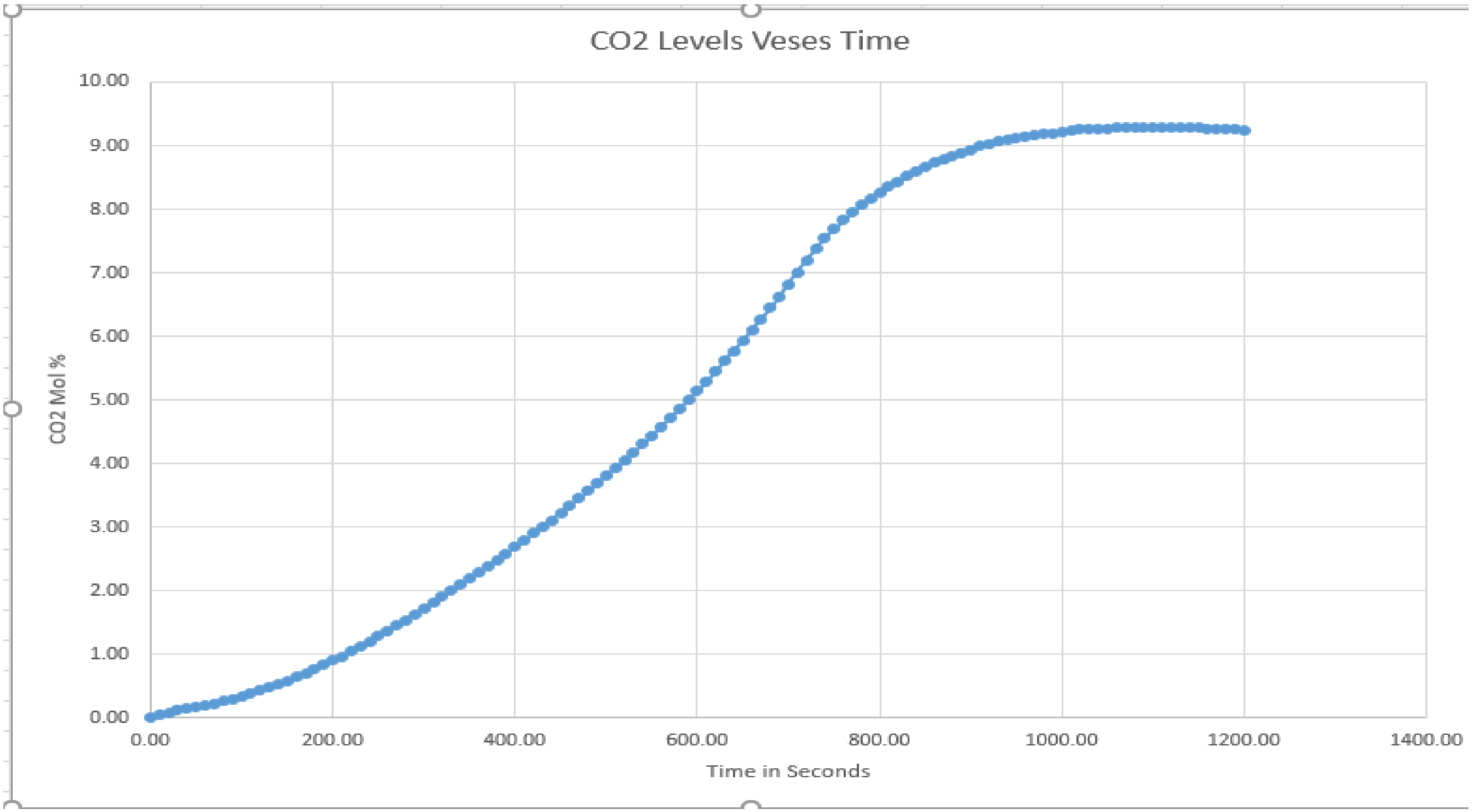


Figure 18 Tenability Parameter for CO2 levels Verses Time for the Large Meeting Room

Therefore, the limiting ASET factor (tenability factor) that was reached by CFAST: Time at which Visibility Level reached 6 feet or 1.8 m was 520 seconds

.

9.6 Performance Based Analysis Conclusion:

Therefore, the limiting ASET factor (tenability factor) that was reached by CFAST model verification was the time the Visibility Level reached 6 feet or 1.8 m which was 520 seconds (8 minutes and 40 seconds) Figure 17 above.

- **Required Safe Egress Time (RSET):**

  Four factors combine to determine RSET:
  1) Notification (or alarm) Time
  2) Reaction Time
  3) Pre-Evacuation Activity Time
  4) Travel Time

  - **Notification Time** is the time between fire ignition and the moment when occupants become aware that there is ***10 seconds***.
  - **Reaction Time** is the time during which occupants take stock of what is happening, and perhaps begin to question one another about what to do, assess the hazard to themselves, and then decide to take action. Granted that these occupants are highly trained nuclear personal and have taken part in numerous safety training and fire drills a reaction time of ***30 seconds*** is used for this scenario.
  - **Pre-Evacuation Activity Time** is the time during which occupants collect their belongings, close books and laptop computers, and prepare to evacuate after deciding to take action. A pre-evacuation activity time of 30 seconds.
  - **Travel Time:** Calculated with a simple linear equation for number of occupants in the fire Area and travel distance based on occupants travel speed which is based on the occupant's physical capacity.

  RSET Number of Occupants in Fire Area: 18 occupants travel down 2 paths of egress along each side of the table in the meeting room to one exit where longest travel distance is 52 FT.

  Occupant Density: person/unit area = 18 occupants/360 sq. = .005 people/sq.

  Occupants Average Movement Speed Based on Physical Capacity: Speed of movement S=k-(akD), where S= Speed along the line of travel, K=constant from Table 4.2.5, where Table 4.2.5 of NFPA HB K const= 275, a= 2.86 when calculating speed in ft./ min:
  Therefore, S= 275-(2.86 X 275 X .005 people/sq.) = 235.675 ft./min=3.927 ft./sec

<u>Executive Meeting Room:</u>
Four RSET elements summed up as follows:
Notification time of 10 seconds plus Reaction Time of 30 seconds plus Pre-Evacuation Activity Time of 30 seconds plus Travel Time of 13.24 seconds = **83.2 seconds (1 minute and 23 seconds)**

9.7 Conclusion for Performance Based Fire Scenario 1:

Since the limiting ASET factor (tenability factor) that was reached by CFAST model verification was the time at which the Tenability Limit for when the Visibility Level reached 6 feet or 1.8 m which was 520 seconds (8 minutes and 40 seconds) as depicted in Figure 16 above.

<u>Conclusion to Performance Based Fire Scenario I</u>
Since ASET> RSET= 520 seconds (8 minutes and 40 seconds) > 83.2 seconds (1 minutes and 23 seconds)

Conclusion:
Since the limiting ASET factor calculated by CFAST was the time at which Visibility Levels reached 6 feet or 1.8 m was 520 seconds (8 minutes and 40 seconds), automatic sprinkler detectors will take 4.04 minutes to actuate, and RSET for the large meeting room was 83.2 seconds (1 minutes and 23 seconds the egress capacity and fire protection systems are deemed as being adequate.

10.Report Summary, Conclusion, and Recommendations

The fire protection and life safety systems for the Building X were evaluated throughout the body of this report and deemed to be in compliance with applicable nuclear power plant non-power block regulatory requirements, NEIL, INPO, IBC, and NFPA design requirements, codes, and standards. This one-story building has two internal balconies with 10 occupants per balcony. It is made of non-combustible materials that also has a partial basement with concrete walls (is normally unoccupied). This building houses potable water pumps and piping for the facility met all of design requirements for mixed occupancy per the International Building Code (IBC) and the Life Safety Code (LSC).

As depicted within the body of the report, the fire protection and life safety systems were designed, installed, acceptance tested, and are maintained in accordance with the applicable NFPA code and NEIL Loss Prevention Requirements.

The following design objectives were met for detection, alarm, suppression, and egress from a prescriptive and performance based analysis as summarized in the following paragraphs:

1. A structure shall be designed, constructed, and maintained to protect occupants who are not intimate with the initial fire development for the time needed to evacuate, relocate, or defend in place.

2. Structural integrity shall be maintained for the time needed to evacuate, relocate, or defend in place occupants who are not intimate with the initial fire development.

3. Systems utilized to achieve the goals of Section 4.1 of the LSC shall be effective in mitigating the hazard or condition for which they are being used, shall be reliable, shall be maintained to the level at which they were designed to operate, and shall remain operational.

Since Building X has an automatic supervised sprinkler system throughout the facility, the requirement for the building to have separated 2-hour fire resistant rated construction was relaxed to a separation of occupancies of 1-hour fire resistant rated construction in accordance with sec 6.1.14.4.3 of the life safety code. However, since Building X has separation of occupancies of 1 or 2-hours, it met and in some cases exceeded the relaxed 1-hour requirement.

The wet pipe sprinkler system in the room was evaluated and it was determined from a performance based analysis the sprinklers would actuate in 4.04 minutes, which is well before the Visibility Levels reached 6 feet or 1.8 m in 520 seconds (8 minutes and 40 seconds), which would render the room uninhabitable.

Based on the hand calculations in Appendix B the minimal required egress time for the calculated allowable capacity of 970 occupants was 14 minutes and 15 seconds. This would result in a large number of occupants being exposed to cumulative untenable conditions in the form of toxicants Building X. However, a more subjective analysis was achieved with the performance based analysis depicted below. One fire scenario was used in a performance based fire protection analysis to validate fire protection and life safety systems. CFAST was used to create a fire model for an upholstered chair fire in a large furnished meeting room. This room has one exit where the door is closed on the northeast side of the building where 18 occupants are attending a meeting.

The life safety and fire protection systems met the performance based design objectives and were deemed as adequately designed for the following reasons:

1. Since the limiting ASET factor calculated for the large meeting room by CFAST was when Visibility Levels descending to 6 feet which was at 8 minutes and 40 seconds which was over 7 minutes greater than RSET of 1 minutes and 23 seconds for the 18 occupants to egress from the large meeting room

2. Since the automatic sprinkler system would actuate in 4 minutes and the he temperature would be gretaly reduced. The smoke would descend 4 minutes prior to when the large meeting room was predicted to become uninhabitable. Visibility would become limited 1 minute and 33 seconds before temperatures would reach 60 degrees Celsius (which took 6 minutes and 33 seconds).

Recommendations:

Since the life safety and fire protection systems meet the performance based design objectives and goals ASET>RSET no design recommendations are warranted at this juncture.

APPENDIX A

All notes below apply to the floor plan in the Pdf of the floor plan in Figure 3.

Note: The life safety code (2009 edition) was the COR used for this analysis. Building X was considered a mixed occupancy. The occupant loads were based on business occupancy classification for the majority of the building although assembly also took place in other areas, and storage /mechanical and Factory F-1 occupancy in the building exist as well as designated in the table below.

Code Applicability:

1. Since the Building X is new and is sprinkled Per NFPA HB Table 4.3.3 for business occupancy the common path limit is 100 feet and the relative travel distance limit is 300 feet and for assembly the common path limit is 75 feet and the relative travel distance limit is 250 feet which has been met as shown in the previously illustrated Egress Floor Plan in Figure 3.

2. Rooms labeled as classrooms were classified as business occupancy in accordance with section 304.1 of the IBC [Ref: 7].

3. In accordance the two vertical openings that lead to the balconies have a 2-hour fire resistance rating and satisfy the requirement in LSC section 8.6.5(1).

4. All interior wall and ceiling finishes in exit enclosures in the two stairways leading from Balcony A and Balcony B have been constructed as class B in compliance with LSC section 7.1.4.2.

5. All interior floor finishes in exit enclosures are Class II and satisfy the requirements in LCS section 7.1.4.2.

6. All exit door tactile signage has been marked and position in accordance with LSC section 7.10.

7. The longest travel distance (which is sprinkled in this new building) is 188 feet from most remote point to the exit and does not exceed 300 feet in accordance with LSC 38.2.6.3.

Floor Plan Designators:
Please see Figure 3 previous page 14.
ACTUAL OCCUPANT LOADS = Respective calculated loads rounded up to the next hole number.

1. EXIT ACCESS- Portion or means of egress that lead to the entrance of an exit is shown on the floor plan as a thin single or double lined triangle with the number that are using the exit access inscribed inside the triangle. Note, the letters ‘EA” denote EXIT ACCESS where there is no prescribed occupant flow. Due to the infrequency of randomly occupied areas (i.e. the men’s bath room, other rooms) it was assumed that egress capacity and door specifications including effective door width would not need to be designated for areas without listed occupancies depicted in the floor (since these occupants were accounted for and included as part of the egress analysis from their assumed permanent location already depicted on the floor plan) plan for the room the door provides exit access from (see previously illustrated Egress Floor Plan in Figure 3.).

However, the possible exit accesses from these respective rooms were designated in case occupancy did occur. All horizontal exit access doors from respective zones are 44 inches with a clear width of 40 inches.

1. TRAVEL DISTANCE AND PATH OF TRAVEL are denoted by the bold line connected to a circle which pinpoints the most remote point from the exit, where the travel distance is measured from the most remote point in a room or floor area to an exit has been annotated on the bold line (see the previously illustrated Egress Floor Plan in Figure 3) [Ref:3]. In most cases the travel distance can be increased if the building is completely protected with a standard supervised automatic sprinkler system which is the case for this building.

EXIT- Portion of a means of egress that is separated from the area of the building from which escape is to be made by walls, floors, doors, and other means that provide the protected path necessary for occupants to proceed with reasonable safety to the exterior of the building. An exit may comprise a vertical and horizontal means of travel, such as exterior doors, protected stairways, ramps, and exit passage ways are shown as bold triangles with the number of occupants that use that respective exit inscribed inside the triangle (see the previously illustrated Egress Floor Plan in Figure 3) [Ref:3].

EXIT DISCHARGE-The portion of a means of egress between the termination of the exit and a public way are represented with the letters’ ED’ (see the previously illustrated Egress Floor Plan in Figure 3) [Ref; 3].

EXIT LIGHTS- Battery Powered exit lights which have been installed in accordance with the LSC 7.10.1.2 are shown as circles where 2/4 of the inner quadrants of the circles shaded.

APPENDIX B

Fire Safety Management Plan for Building X

1.0 Introduction

A Fire Management Safety Plan for Building X is provided in this report. Building X was constructed 4 years ago as a support structure for the nuclear power plant therefore much of the detailed information regarding building X cannot be disclosed for proprietary reasons. Note I did not retain the position of fire protection engineer until after the building was built and occupied. Thus the extent of my knowledge on details of the documents submitted to the insurer NEIL and other AHJs are limited to the time frame.

The Fire Management Safety Plan depicted below has been developed for the entire life cycle of the building and is broken down into the three following phases, initial design and construction, demolition and destruction, and occupancy and operation. Although some of the information presented in the following sections has already been presented in previous sections of this report this information was presented again for its direct applicability in regards to this Fire Management Safety Plan.

2.0 Background

Sections I, II, and III listed below play a vital role in the requirements, subject areas, and level of required adherence to regulatory codes that is depicted within this Fire Safety Management Plan.

I. Regulatory Requirements:

Building X is only required to meet either the prescriptive requirements or performance-based goals and objectives to be in compliance with NEIL the insurer's requirements. However, based on the analyses depicted in the LSC, building X meets both the prescriptive life safety requirements and satisfies the performance-based goals and objectives defined in the LSC.

Code of Record:

The code of records for Building X is the September 2010 NEIL Loss Controls Standards which supersedes (but in most instances references the NFPA requirements). The NEIL Loss Controls Standards defines the regulatory and or code requirements to which the fire protection systems will be designed, built, maintained and inspected too. In most instances the NEIL Loss Controls Standards defers to applicable NFPA codes.

In addition, the IBC 2006 edition, LSC 101 2009 edition, NFPA 72 2010 edition, NFPA 13 2010 edition, NFPA 20 2009 edition, and NFPA 25 2009 edition are referenced as applicable code of records. The IFC 2012 edition was used to provide guidance for maintaining the operating systems and fire safety during the construction and demolition and destruction phase. The IFC and the provisions it contains was not considered or used as regulatory document.

Authority Having Jurisdiction:

Since Nuclear Electric Insurance Limited (NEIL) insures all support (i.e. Building X) and power block structures NEIL serves as the primary authority having jurisdiction (AHJ). In addition, the Institute of Nuclear Power Operations (INPO) and the Nuclear Regulatory Commission (NRC) serve as secondary AHJs. Since this is a support structure for the nuclear facility located in Waynesboro Georgia the state fire Marshall is not the cognizant fire code authority or AHJ.

II. Goals for Fire Protection System:

A single source fire was assumed when performing the egress evaluation developing the fire protection system [Ref: 1].

The following two goals set forth in the life safety code provide concise deliverables that can be achieved by the objectives listed below:

3. Protection of occupants not intimate with the initial fire development
4. Improvement of the survivability of occupants intimate with the initial fire development [Ref: 1].

Fire Protection System Design Objectives:

Detection, alarm, suppression, and egress are the four primary areas of fire protection that were addressed with respect of achieving the following objectives:

1. A structure shall be designed, constructed, and maintained to protect occupants who are not intimate with the initial fire development for the time needed to evacuate, relocate, or defend in place.
2. Structural integrity shall be maintained for the time needed to evacuate, relocate, or defend in place occupants who are not intimate with the initial fire development.
3. Systems utilized to achieve the goals of Section 4.1 of the LSC shall be effective in mitigating the hazard or condition for which they are being used, shall be reliable, shall be maintained to the level at which they were designed to operate, and shall remain operational [Ref: 1] [Ref: 5].

III. Performance Criteria and Design Attributes:

Since NEIL's (the agency that carries the insurance policies on commercial nuclear power facilities) primary concern is protection of property, efforts to promote life safety in fire protection system design and fire protection program implementation often fall by the way side. However, going forward this was not the thought process going forward with the fleet. In addition, previous egress systems and pre-fire plans for nuclear facilities were based on the theory that the building and equipment would be abandon in place opposed to defense in depth FP design measures which are geared towards performance based design for fire protection and fall in line with NFPA 805 objectives that power plants are currently being upgraded in accordance with.

The following performance attributes which are defined in the NFPA handbook for life safety that parallel the protection of property objectives for nuclear fire protection requirements defined in the NEIL requirements were both taking into account with the design of building X's fire protection system and development of relative egress procedures [Ref: 14, pg. 4-73]:

1) Sufficient number of properly designed, unobstructed means of egress of adequate capacity and arrangement
2) Provision of alternative means of egress for use if one means of egress is blocked by fire, heat or smoke
3) Protection of the means of egress against fire, heat, and smoke during the egress time determined by the occupant load, travel distance, and exit capacity
4) Subdivision of areas by proper construction to provide areas of refuge in those occupancies where total evacuation is not a primary consideration
5) Protection of vertical openings to limit the operation of fire protection equipment to a single floor
6) Provision of detection of alarm systems to alert occupants and notify the fire department in case of fire
7) Adequate illumination of the means of egress
8) Proper marking of the means of egress and the indication of directions
9) Protection of equipment or areas of unusual hazard that could produce a fire capable of endangering the egressing occupants.
10) Initiation, organization, and practice of effective drill procedures
11) Provision of instructional materials and verbal alarm systems in high-density and high-life hazard occupancies to facilitate adaptive behavior
12) Use of interior finish materials that prevent a high flame spread or dense smoke production that could endanger egressing occupants

The fire protection system was designed to satisfy the ***Systems Effectiveness*** and provide the facility with a reliable system those possesses the ability to mitigate a fire hazard [Ref: 1 sec 4.2.3].

This report satisfies the provision of a documented [Ref: 5]. Non-compliances to prescriptive analysis as depicted in NFPA 101 [Ref 1] were documented and a recommendation made for either requesting an equivalency from the Authority Having Jurisdiction (AHJ) or identifying additional compensatory measures to mitigate the adverse consequences of fire. NEIL reviewed, approved, and documented all equivalencies in accordance with NFPA 101 sect 1.4 [Ref: 1] [Ref: 5].

The design was reviewed against IBC 2006 edition, LSC 101 2009 edition, NFPA 13 2010 edition, NFPA 20 2009 edition, NFPA 25 2009 edition. All acceptance test and design reviews were conducted and documented in accordance with the applicable codes. The result of these tests was excluded from this document since they were not the objective of this report.

3.0 General Building Characteristics

Building X is a one-story building with two internal balconies with 10 occupants per balcony, which is made of non-combustible materials that also has a partial basement with concrete walls (is normally unoccupied), which houses potable water pumps and piping for the facility.
Building elements requirements for this TYPE III B Fully Sprinkled Building per section 602.2 are listed in Table 602 of the IBC 2009 edition (shown below) and are as follows:

Table 1 Per Table 601 of the IBC 2009 edition the fire resistance rating for building elements (hours).

	TYPE B	
Building Element	A	B
Primary Structural Frame	1	0
Exterior Bearing Walls	2	2
Interior Bearing Walls	1	0
Non-Bearing Walls and Partitions Exterior	See IBC Table 602	
Non-Bearing Walls and Partitions	0	0
Floor Construction and Secondary Members	1	0
Roof Construction and Secondary Members	1	0

There are two sets of interior stairs that go up to the balcony, the partial basement is accessed through an external door down at the basement location (building is orientated on a hill). Both sets of internal stairs have 2-hour fire walls that protect their vertical openings their construction exceeds the requirements of the LSC Table 8.3.4.2 by requiring a 1-hour minimum protection rating [Ref:1]. The stairway construction satisfies the following LSC requirements for section 7.2.2.5.1 Enclosures. 7.2.2.5.1.1 All inside stairs serving as an exit or exit component shall be enclosed in accordance with 7.1.3.2. 7.2.2.5.1.2 Inside stairs, other than those serving as an exit or exit component, shall be protected in accordance with Section 8.6.

4.0 Occupancy and Operation Safety Management

Prevention, detection and alarm, and suppression of fires are the main elements of fire protection addressed for protecting occupied structures.

I. Occupancy Life Safety:

Building X is used as a support structure with a classified occupancy for business and assembly (A-/ A-3 per the IBC). This building is considered to be mixed occupancy therefore per section 302.1 each portion of a building shall be individually classified in accordance with section 305.2 of the IBC. Where a building contains more than one occupancy group, the building or portion thereof shall comply with section 508.3.1, 508.3.2, 808.3.3 or a combination of these respective sections[Ref:2]. For a mixed occupancy, the LSC requires the application of the most restrictive requirements per LSC section 6.1.14.

This building also falls under the definition of mixed occupancy in LSC sec 6.1.14.2.2 where a mixed occupancy is defined as being a multiple occupancy facility where the occupancies are intermingled. Per table 6.1.14.1(b) of the LSC the two occupancies must be separated 2hour fire resistant rated construction. However, since the entire building has an automatic supervised sprinkler system this requirement has been relaxed to a separation of occupancies by a 1-hour fire resistant rated construction in accordance with sec 6.1.14.4.3 of the life safety code (which was previously illustrated in the Egress Floor Plan in Figure 3) [Ref:1]. Therefore, Building X exceeds the requirements of separation mentioned above. The requirements were exceeded in cases where SNC defined to the AE that additional separation was warranted in lieu of protecting specified assets.

II. Egress and Evacuation Plans:

Based on the tenability analysis presented in section 7.1 of the Egress Analysis and Design chapter an estimated time for incapacitation assuming a linear increasing rate of CO of 1000 ppm/min and a CO2 concentration increasing at 1% per minute was estimated to be between 5 and 6 minutes. The maximum predicted evacuation time for the 970 occupants located accessing exit discharges with a Max Flow of 56 people per minute from Building X is a little over 6 minutes and 40 seconds as shown in Table 9 of Appendix B. Based on the hand calculations Building X current design configuration the concentration of CO and CO2 would incapacitate a large number of the 970 occupants.

Based on the hand calculations in Appendix B of the Egress Analysis and Design chapter since the minimal egress time for all occupants is 6 minutes and 40 seconds which would result in a large number of occupants being exposed to cumulative untenable conditions in the form of toxicants Building X does not meet the performance criteria specified in LSC section 5.2.2.

Since the maximum available safe egress time (ASET) is 6 minutes before occupants would be exposed to concentrations of CO and CO2 is less than the required safe egress time (RSET) of 6 minutes and 40 seconds, which is the time require for all 970 people to exit the building, it was brought to the attention of the facility manager that this structure did not meet NFPA 101 recommendations for egress capacity set forth in Appendix A.4.8.2.1.

III. Fire Response:

It should be noted since Building X is a support structure a memorandum of agreement was put in place with the state fire marshal that the first responder to non- power block support structures would be the site fire brigade and the local fire department would serve as a back -up upon being notified by operations during a fire event. During a fire event the fire brigade lead is in charge of leading the team in firefighting actions, updating Operations and the Facility Manager, and assisting occupants in egress from the building. The Fire Brigade lead will serve as the first interface with offsite state or county fire prevention and emergency units that arrive on the scene.

Per section 401.7 of the International Fire Code (IFC) any evacuations that result from an unplanned activation of fire alarm system or any other emergency shall not be substituted for a required evacuation drill. [Ref: 6]. All of the aforementioned actions have been captured in the Fire Response Procedure. An evacuation plan with highlighted areas of refuge, paths of egress, exits, and rally points and crowd manager, extinguisher and manual pull station locations, are affixed outside each room within the building. There is no critical equipment to be operated within this facility and all occupants except the fire brigade are charged with using the egress plan in their area and egressing from the facility and proceeding to their respective rally point in accordance with section 404.2 [Ref: 6].

In accordance with the fire response procedure all fire doors are to be kept shut and all doors are to be kept in the closed position along with all windows. Per the Fire Response Procedure there are no lock downs for this facility. The Fire Response Procedure and Fire Pre-Plans is required reading for applicable personal. A copy of the Fire Response procedure and Fire Pre-Plans is located in a designated area in each fire zone and the Facility Manager and Operations Training Manager's office. Upon deeming it safe to return inside the facility the Fire Brigade Lead will confirm via radio to Operations the all Clear, if the order is accepted by OPs, the lead is instructed to convey the all clear to the facility manager who conveys the all clear to the rally point crowd manager who convey all clear to the occupants and escort them back in the facility. The Fire Pre-Plans and Fire Response Procedure are revised annually at the minimum in accordance with section 404 of the IFC [Ref:6]. The facility manager, the training manager, and fire protection engineer have keys and access to turn off the fire alarm panel a possess the verbal codes to call and give the remote monitoring station in the event of a false alarm.

Notification Appliance Type, Alarm Signals, and Location:

Audible Notification Appliances (NA)for Public Mode Audio Requirements per NFPA 72, 18.4.3 were selected (See Appendix C for NA cut sheet) and located such that the sound level of a 3 pulse temporal tone which is required per NFPA 72, 18.4.2.1 would be less than 75 dBA at 10 ft. Since the average ambient noise level per NFPA 72 Table A .18.4.3 for a business building is 55 dBA , 70 dBA audible appliances were selected which meets the 15 dBA above the average ambient noise level (which is 55 dBA for a business building) and last for a duration of 60 seconds as required per NFPA 72, 18.4.3.1. The candela strobes meet the requirements of NFPA 72-2010, sec 18.5 which states where in accordance with 18.5.2 the flash rate between 1-2 Hz through of the listed voltage range max pulse duration of 0.2 second, defined as interval between 10% of max signal. Maximum cycle of 40% lights used for fire alarms or complete evacuation shall be clear or white and shall not exceed 100cd effective intensity. Therefore, the building's audible notification appliances meet NFPA requirements.

All building occupants will be notified by visible and audible notification through the use of the following appliances located at their list locations which can be seen in the previously illustrated Egress Floor Plan in Figure 3) 4 Horn Strobe/75 CD, Wall Mount Red Wheelock HSR located 80"A.F.F. to the center lens.

57 Speaker Strobe/75 Multi-Candela Wheelock E50-24MCW-FR located 80"A.F.F.
75 Strobe, Selectable Candela Wall Mount Wheelock STR located 80"A.F.F.
8 Addressable Relay Module Notifier FRM-1 located as needed
1 Universal Digital Alarm Communicator/Transmitter Notifier UDACT located as needed.
2 Digital Audio Amplifiers Notifier DAA-5025 located 66" A.F.F. to top of cabinet.
1 Digital Voice Evacuation Control Panels Notifer DVC-EM located 66" A.F.F. to top of cabinet.
4 Field Charger Power Supply Amps Notifier FCPS-24S8 located 66" A.F.F. to top of cabinet.
2 Sprinkler Valve Tamper Switches By Others By Others By Others
2 Sprinkler Water Flow Switches by Others by Others by Others
4 Surge Suppressor,120 VAC DTK-120HW Mounts in Panel cabinet.

Any occupants external to the building that are in close proximity to the mechanical room will hear a water gong once water flow greater than 7 gpm occurs in the riser that supplies water to the building sprinklers. In addition, all rooms and hallways have strobes for visible notification of fires. The Notifier Emergency Command Center located in the basement provides manual voice override capability that will be provided to emergency response personnel via a microphone.

Wiring to signaling line circuits and notification appliance circuits are Class B. Pathway survivability and meets Level 2 per NFPA 72, 12.3 using two-hour CI cable.

This fire alarm and emergency voice alarm system will transmit both alarm and supervisory signals to ADS which is a UL listed central station service. ADS will immediately contact the Burke County Fire Department and the Control Room to initiate an emergency response to a possible fire. Alarm, Supervisory, and Trouble signals will show up on the Notifier Emergency Command Center and alarm panel and issue and audible alarm and an LCD alarm description at the panel in the main hall way, where that Supervisor or Trouble signal will in turn be transmitted by the UDACT to the central station, who will in turn contact building maintenance to confirm if they are aware of the signal.

IV. Emergency Response and Preparedness:

1. Fire Drills:

Personal that occupy this facility are highly trained and participate in quarterly announced and unannounced drills as required by NEIL. This training has a positive effect on the delay times as mentioned in section 7.2 Detection and Alarm System Design. These drills satisfy the recommendations and requirements set forth in section 4.1.3 of the NEIL Loss Control Standard stated below.

4.1.3.2 Frequency

1) A Fire Brigade Drill "should" be arranged by the plant so that it can be witnessed by the Property Loss Control Representative annually.
2) NEIL, through the discretion of the NSO Property Loss Control Representative may and can extend the frequency for witnessing Fire Brigade drills to a maximum of 24 months provided all of the following criteria are met:
    - Performance of the fire drill would affect plant safety due to an unexpected plant condition.
    - Drill Performance previously witnessed by NSO has been ACCEPTABLE.
    - A review of previous drill critiques and corrective actions taken show management attention to Fire Brigade performance and improvement.
    - NSO has not identified problems with the content and implementation of the Fire Brigade program.
3) A Fire Brigade Drill SHALL be arranged by the plant so that it can be witnessed by the Property Loss Control Representative at least every 24 months [Ref: 5].

4.1.3.3 Implementation

The Property Loss Control Representative must consult with the Site Contactor Fire Brigade Drill Controller at the site to ensure the proposed drill scenario addresses the requirements in the NEIL Property Loss Control Standards.

2. Fire Brigade:

The fire brigade is selected and trained in accordance with the NEIL Property Loss Control Standards, NRC Appendix R requirements, and INPO recommendations. The members that serve on this team are highly trained plant operators that conduct fire drills in this building and other plant structures. Different drill scenarios are presented which require the brigade members to dress out in full brigade gear in most scenarios and communicate to the control room by approved remote communication devices.

Per section 4.1.3 the Property Loss Control Representative will evaluate the Fire Brigade's response to one observed drill in accordance with the NEIL Property Loss Control Standards. In addition, fire drills are conducted every quarter and the documented results are sent to the Property Loss Control Representative who will submit appropriate comments, and if necessary recommendations.

5.0 Construction Safeguards:

During initial construction demolition and destruction many hazards were introduced in and around the building. These new hazards stemmed from grinding, cutting, welding, plumbing, and temporary storage of combustibles. In addition, the building and surrounding area changed constantly which lent itself to occupants being unfamiliar with hazards that constantly changed.

Therefore, some of the systems that were put in place were fire hydrants that would supply the required hose stream for the area under construction. Secondly, a detection and sprinkler system was installed and tested in accordance with the requirements specified in NFPA 72 and NFPA 13 respectfully at the earliest stages of construction. In addition, fire extinguishers were positioned in visible locations throughout the construction site. In addition, designated fire watches were established to perform rounds and report any ignition sources and transient combustible fuel sources in the area that were not approved vis the transient combustible program.

In accordance with section 5.1.8.2 of the NEIL Loss Control Standard the following written procedures addressing the following were submitted to NEIL for review, ACCEPTANCE, and/or comment:

- Private Fire Brigade program
- Property Loss Control Surveillance program
- Welding and Cutting (hot work) control program
- Impaired Fire Protection System procedure
- Fire Incident Reporting Process
- Housekeeping/Combustible Controls Process
- Work Control/Prioritization Process
- Temporary Structures Process
- Oversight of Construction Activities

I. Hot Work and Transient Combustibles:

The hot work and transient combustible permit program was utilized to control and put proper controls in place for grinding, cutting, and welding which can produce sparks and ignition sources. Proper temporary shielding per site hot work procedures were put in place and evaluated during rounds made by the fire watch or other designated personal.

Transient combustibles and applicable MSDS sheets were logged and maintained in designated areas where the fire protection engineer had evaluated and defined the acceptable levels that can be stored in accordance with the transient combustible permit program. The fire protection engineer is responsible for tracking the ignition sources and combustible loads in the area; he is assisted by Ops and the facility manager in this initiative.

The aforementioned hydrants, extinguishers, detection and sprinkler systems, and transient combustible and hot work programs will be used to provide fire safety both at initial construction and demolition and destruction.

The aforementioned hot work and transient combustible permit programs were utilized to satisfy the following applicable NEIL section 5.3.4. Housekeeping requirements:

Per section 5.3.4.1 all General Housekeeping was maintained so as to minimize the probability of a loss. The Transient Combustible Program met the following recommendations specified in 5.3.4.2 which recommended that temporary combustible storage, including forms, “should” be arranged so as not to expose completed structures, equipment or facilities under construction. Per section 5.3.4.3 combustible waste “should” not be permitted to accumulate in excessive amounts. Per section 5.3.4.4 any accumulated combustible waste “should” be disposed at least once per shift or more frequently as necessary.

During construction and post construction smoking was and is still not allowed within the building and was only allowed in designated smoke areas at least 50 feet from the building structure. In order to meet the requirement in section 5.3.4.5 which states smoking SHALL be controlled and not permitted in areas with combustible formworks, combustible storage, or storage of combustible or flammable liquids.

Ignition sources were limited and maintained by the hot work and transient combustible permit program, in addition to the surveillances that were performed by designated staff in accordance to the fire prevention procedures which satisfied the following requirement of section 5.3.5 for Ignition Sources:

Per section 5.3.5.1 ignition sources SHALL be controlled by an ACCEPTABLE written procedure, which includes cutting, welding, burning, grinding, torches, tar kettles, etc.
Per section 5.3.5.2 ACCEPTABLE welding and cutting and other hot work safety procedures SHALL be established utilizing NFPA No. 51B and NFPA No. 241 as a guide.

1. A program SHALL be established in writing and enforced by detailing definite assignments and fire prevention procedures to be followed in areas where welding, cutting or other hot work operations are in progress.
2. A permit system SHALL be provided to positively control all hot work in site areas other than "designated" welding areas. The permit system SHALL be such that no welding would be allowed unless approved by appropriate supervisory personnel [Ref:3]. In accordance with section 5.3.5.3 records “should” be retained for review. Per section 5.3.5.4 a Hot Work Fire Watch SHALL be provided for each work area unless a Dedicated Hot Work Station is established meeting the requirements of Section 5.3.5.8. Per section 5.3.5.5 a Hot Work Fire Watch SHALL be trained in the use of portable fire protection equipment. Per section 5.3.5.6 a Hot Work Fire Watch SHALL remain in the area for a minimum of 30 minutes following the completion of hot work operations to confirm and ensure that safe conditions exist. Per section 5.3.5.7 Fixed Dedicated Hot Work Stations were provided with all of the following requirements being met per the Hot Work procedure:
   1. Fixed Dedicated Hot Work Stations “should” be located in noncombustible structures.
   2. All combustibles not necessary for the work being performed “should” be removed from the area.
   3. Noncombustible covers “should” be provided at unprotected openings in floors or walls between the station and other areas.
   4. An adequate number of portable fire extinguishers “should” be provided in the station.
   5. A minimum of 35 feet of open clear space or noncombustible enclosures “should” be provided to separate the station from other combustibles.

II. Fire Prevention and Safeguarding

1. Housekeeping and Ignition Sources:

General Housekeeping and Ignition Sources are maintained and the probability of a loss is minimized by implementation and use of the transient combustible program that is documented in section 7.0.I Hot Work and Transient Combustibles above. Approved Fire Cabinets are used to store materials susceptible to spontaneous combustion in fire zones designated for transient combustibles where either automatic sprinkler protection or direct access to standpipe and hoses are available.

2. Temporary Services:

All temporary heating devices used during construction were positioned, maintained, and evaluated by operations per the temporary equipment procedure in accordance with the following NEIL recommendations and requirements. Per section 5.3.6.1 temporary heating devices and their fuel supply systems SHALL be UL Listed or FM Approved and installed in accordance with the manufacturer’s guidelines. Per section 5.3.6.2 all acceptable procedures addressing the installation of temporary services (i.e., cables, hoses, heating devices, etc.) "should" be established and implemented. Per section 5.3.6.3 Temporary Services “should” be installed in accordance with ACCEPTABLE
procedures. 5.3.6.4. Electrical wiring and equipment "should" be installed in accordance with NFPA No. 70, National Electrical Code. 5.3.6.5. The electrical supply for each temporary structure "should" be capable of being de-energized from outside the structure by a single switch that is clearly marked. Per section 5.3.6.6 temporary services to these structures "should" be shut off when not in use. Per section 5.3.6.7 non-permanent electrical circuits required for temporary power and lighting installations "should" not be placed in cable trays with permanent circuits unless they meet the same requirements as permanent circuits [Ref:3].

There were no temporary structures within 60 yards of any portion of the building only lay down areas used.
Laydown areas were located near fire hydrants which could provide adequate hose stream to suppress a fire if any of the combustibles in the lay down area were to catch on fire.

3. **Other Hazards**
In accordance with section 5.3.7 no internal combustion engines were only housed in areas where automatic sprinkler protection was provided. No explosive materials or Cadweld were stored or handled anywhere on the construction site [Ref:3].

4. **Hydrogen, Flammable Gases, and Flammable Combustible Liquids**
Combustible and flammable liquids were stored and logged as transient combustibles in accordance with the transient combustible program and NFPA 30 [Ref:3].

5. **Fire Prevention**
In accordance with recommendations in section 5.3.9 acceptable alarm and nonfiction system independent of the communication system was installed, tested, and is maintained in accordance with NFPA 72[Ref:3]. The system has fixed repeaters and battery backup and sends signal to an offsite monitoring station. Surveillances for fire watches were created and implemented for the laydown area and construction site in general. Post construction fire watches are performed on 12 hour shifts.

6. **Fire Pre-Plans**
The fire Brigade which reports directly to Operations is responsible for using the Fire Response Procedure and Pre-Fire Plans to address actual fires and conduct fire drills in accordance with NEIL Loss Control Standard section 4.2.2.1.3 which states establish fire response pre-plans to all NEIL insured areas of the site[Ref:3]. Emergency vehicle parking designations, travel routes, hydrant locations, and fire cabinet (which connect hoses and hydrant connections) locations as well as areas of refuge and assembly areas have been called out on the Fire Pre-Plans. The Fire Pre-Plans also list prioritized vital equipment (in the power block this would be safety significant or safe shut down equipment) to protect, detection and suppression, portable extinguishers, egress path, fuel hot spots, MSDS sheets for any hazards, and exits within each fire zone.

7. **Documentation, Initial Design, and Construction General Documentation Requirements:**
Although Building X is a support structure Chapter 5 NEIL Construction Period Loss Control Standards provides the requirements that Sothern Company has to adhere to during construction since the Building is insure by NEIL. The requirements for installation and maintenance for both temporary and permanent fire protection systems are the same. All temporary and permanent fire protection system should be installed in accordance with their applicable codes (i.e. NFPA 13 (2010) for automatic sprinkler systems) which have been depicted in greater detail section 7.1 II below in accordance with the NEIL Loss Control Standard section 5.3.12 [Ref:3].
One important requirement of the NEIL Loss Control Standards is that members (nuclear power plants) must submit information for both temporary and permanent fire protection system design documents and drawings that could affect Property Loss Control to NEIL in accordance with NEIL Loss Control Standard section 5.3.12.2. [Ref:3]. This is part of and what is referred to as a NEIL Design Review.
A NEIL design review is required for the construction of structures, systems or components that will be:

- Insured by NEIL,
- Permanent (i.e., in place over 180 days),
- Covered by the guidelines provided in the NEIL Standards, Section 1.9.

Per section 5.1.4.2.1 of the NEIL Loss Control Standard all reports generated from fire protection loss control audits generated from NRC Fire Protection Inspection Reports, Quality Assurance Department Fire Protection Audits and Assessments, and Fire Protection Programmatic Self Assessments that are used y to assess the adequacy of fire Protection programs including organization, administrative procedures, and quality

Assurance procedures and reports were provided to NEIL [Ref: 3].
The Construction Period Document List for the Property Fire Protection Loss Control Program is defined as follows per section 5.1.8 of the NEIL Loss Control Standard:
Per section 5.1.8.1 Examples of Construction Period Documents / Drawings / Specifications to be submitted for review, ACCEPTANCE, and/or comment by NEIL for the plant under construction and construction associated facilities. In addition, other documents may be requested as required.

1. Overall layout of entire construction site (plot plan): Identification of all buildings where the building and contents insurable values will exceed $150,000. Construction and occupancy drawings for all buildings, including wind design criteria.
2. Layout of warehouse storage configurations (i.e., details on rack storage arrangements).
3. Details of the construction water supply for use in fire protection during construction (source and pumping) to include hydraulic calculations for the largest fixed water extinguishing system.
4. Working drawings for all fire protection related systems; sprinklers, deluge, gaseous agents, underground piping, hydrants, control valves, standpipe systems, detection systems, alarm systems, supervisor systems, etc.

NEIL performed periodic inspections on the fire protection systems and the facility every two months in accordance with section 5.1.4.3.1[Ref:3] The Loss Control Representative conducted exit interviews after the site visits with the appropriate supervisory personnel at the plant to discuss the following in accordance with section 5.1.4.3.5 [Ref:3]:

1. Noncompliance with the Loss Control Standards, which were corrected during the evaluation. These will only appear in the "Remarks" section of the Loss Control Report.
2. Recommendations for the correction of conditions that are not in compliance with Loss Control Standards that will appear in the Loss Control Evaluation Report.

In accordance with section 5.1.4.4.2.4 NEIL maintained a log of all recommendations that were issued. Per section 5.1.4.5.1 the Loss Control Representative established specific agendas based on the results of previous evaluations and any issues that may have arisen since the last evaluation. Evaluations included of the following:

1) Reviewed the fire protection organization, fire prevention program, and the implementation of Hot Work, Transient Combustible, and System Impairments program, processes, and procedures.
2) The Property Loss Control Representative reviewed Fire Brigade training and witnessed Fire Brigade drills in accordance with the Construction Period Property Loss Control Standards.
3) Testing of Equipment and Systems Associated with Loss Control
4) The Property Loss Control Representative witnessed and/or reviewed appropriate documentation concerning the acceptance testing of fire protection systems and/or equipment. To ensure it was code compliant.
5) The Property Loss Control Representative witnessed and/or reviewed appropriate documentation regarding the periodic testing of all systems and/or equipment at a reasonable frequency during regularly scheduled site evaluations.
6) The Property Loss Control Representative determined when tests not witnessed during the evaluation were required to be reviewed based on the effect on the overall Loss Control program.
7) All recommendations resulting from the evaluation that did not appear in the Evaluation Report were discussed at the exit interview. (Note: To be done each evaluation. The results of these evaluations cannot be released.

In addition, during the exit interview the NEIL Loss Control Representative discussed all items of concern including those that could possibly result in SHALL recommendation and provided a preliminary assessment of the action level for each shall recommendation. The Loss Control Representative also explained the plants options for addressing the SHALL recommendation as follows:

1. Correct the condition that led to the Recommendation
2. Request a Variance from the SHALL requirement at issue (in accordance with Section 1.7 of the Loss Control Standards)
3. Remove equipment or property from coverage under the applicable NEIL insurance policies.

In accordance with section 5.1.6.5.3 a Loss Control Evaluation Report will be issued to the plant representative following an evaluation by the assigned underwriter within 30 days of the date of the evaluation exit meeting. A compliance development plan will be created and issued to NEIL by the plant to address the concerns in accordance with section 5.1.6.5.4[Ref:3].

I. Initial Design Review:

Per section 5.1.5.1.2 of the NEIL Loss Control Standards provided acceptance and/or consultation during the concept design and construction stages of the project. NEIL reviewed of all designs affecting Loss Control as the specifications and plans are generated for the overall system(s) including details of the structures, systems and components.

Per section 5.1.5.1.3 all designs, specifications, and procedures for all structures, systems and components which affect Loss Control as outlined in the NEIL Loss Control Standards were reviewed. The design review was accomplished by meeting the following the steps outlined in section 5.1.5.2 and 5.1.5.3 listed below.

In accordance with section 5.1.5.2.1 the fire protection engineer submitted the necessary conceptual and design drawings and specifications to NEIL. The fire protection engineer submitted and received acceptance for all vendor and contractor design specifications for the building in accordance with section 5.1.5.2.2. The fire protection engineer addressed all comments prided by NEIL.

Per section 5.1.5.3.1 the fire protection engineer provided at least one copy of each of the Loss Control subject plans, drawings, or specifications to NEIL to retain.

If the member desires that additional copies be. In accordance with section 5.1.5.3.2 NEIL reviewed the design documents supplied and responded within thirty (30) calendar days [Ref:3].

It should be noted that no variances were submitted per the requirement listed in section 5.1.6.1 of the NEIL Loss Control Standard.

II. Fire Protection Systems Required Maintenance, PMs, and Surveillances:

The maintenance, test, and surveillance programs are essential since they ensure the fire protection systems are operable upon demand and can provide the fire detection, alarm, and suppression for the construction site and occupants after the building is completed and occupied.

Although the scope of work for inspection, test, or maintenance task are the same as depicted in NFPA 13(2010), NFPA 25 (2002), NFPA 1962 (2003), NFPA 72 (2002), and NFPA 10 (2002) the frequencies for these tasks for the components listed below are in accordance with the NEIL (the AHJ and insurer of the property) Loss Controls Standards requirements in Chapter 4 and Chapter 5 for construction which supersedes the NFPA requirements for Building X at Plant [Ref:3]. The frequency for major evolutions are generally 18 months which coincides with the plants planned refueling cycle (outages). The required maintenance testing and surveillances that are required for existing systems are defined per the NEIL requirements which reference the applicable NFPA codes as denoted below.

In accordance with section 5.3.12.4 thru 5.3.12.7 of the NEIL Loss Control Standard maintenance, test, and surveillance procedures that were acceptable to NEIL were developed and implemented per

applicable NFPA Standards and/or the manufacturer's recommendations. Fire protection systems and components in construction facilities "should" have testing & maintenance conducted in accordance with NFPA 25, "Water Based Fire
Protection Systems in accordance with 5.3.12.4 of the NEIL Loss Control Standard [Ref:3].

A. Acceptance Testing:

Detection:

Prior to building turnover acceptance test were performed for all input and notification appliances and alarm panels in accordance with NFPA 72 Table 14.3.1 and a record of completion was filled out by the contractor and turned over to me the Fire Protection System/Program Engineer prior to system turnover and full acceptance of the building. This included ensuring that all functions listed on the sequence of operation (i.e., input/output matrix) perform as prescribed; ensuring there are no opens, shorts or grounds; ensuring appropriate sound levels in all occupied areas (i.e., minimum of 70 dBA for the temporal 3 tone generator preceded voice messaging); ensuring all strobes provide the appropriate lamination (minimum of .375 lumens/sq. ft.).

The dual phone line which sends the trouble, supervisor, and alarm signals to the central station (which is UL listed) have been verified. In summery the buildings detection and alarm system is code compliant.

Suppression:

In accordance with sections 5.3.12.3 NEIL the following acceptance test required per NFPA 13 chapter 10 were completed Flushing of Underground Piping, Main Drain Test, and Hydrostatic Test on all permanent building sprinkler pipes, and the Backflow Prevention Assemblies were forward flow tested in accordance with NFPA 13 section 10.10.2.5. A Contractor's Material and Test Certificate for Underground Piping was reviewed by the fire protection engineer and issued to the Facility Manager, Ops, and then NEIL. All required acceptance test were performed for underground pipe in accordance with NFPA 24. All required acceptance test were performed for pumps in accordance with NFPA 20. Contractor's Material and Test Certificate for Underground Piping and Pumps were provided to the Fire Protection Engineer and copies sent to NEIL upon completion of acceptance testing.

(1) **Water Supply and Stand Pipes:**

The Fire Pump House was the first structure that was built in order to provide water for hose streams for permanent standpipes with temporary hose connections and eventually the riser that would be located in the mechanical room of Building X being constructed. The water supply source for these stand pipes and riser is providing from a 101,153 gallon ground level fire water suction tank with a diameter of 32 ft. and 8 inches, is 16 feet tall, and is separated by 20 feet of underground from the connection point to the suction line where the 8-inch ductile iron pipe enters the heated pump house. The water flows from the fire water storage tank through an 8-inch ductile underground pipe though the 8-inch fill pipe inside the heated enclosed pump house constructed and maintained in accordance with NFPA 20. The water then flows through an 8-inch pipe through the diesel fire pump rated at 130 PSI and 750 gpm, through a 4-inch relief valve, through an 8-inch water check valve, through a section of pipe accessed by a test header, through the electric jockey pump, through a potter flow switch, through an 8-inch control valve.

The jockey pump maintains system pressure of the underground pipe from the pump house to the standpipe in the mechanical room of building X between 125 psi and 129 psi. When the pressure falls below 117 psi the diesel pump will kick on until it is shut off manually or until pump failure occurs as prescribed in NFPA 20. The pump house where the diesel and jockey pumps are housed is also protected by a sprinkler system. This water supply which runs underground to the mechanical room (one of the first structures built) in Building X is fed from a class 50 underground ductile 8 inch pipe (that has two free standing fire department connection hose threads to match the connections of the local fire department) which supplies two 4 inch loops of pipe that can be put on line interchangeably, each respective line has a wall post indicating control valve with tamper switch, alarm check valve assembly, pressure gauge, Potter valve type water flow alarm flow switch that is connected to fire alarm panel and a 2 inch elbow that supply the 2 inch cross main lines. Since the standpipe installation meets the design and was installed prior any two-floor equivalent wall being built the standpipe installation met the requirements specified in the NEIL Loss Control Standard under section 5.3.17.

In addition, a hydrant connected to a stand pipe with the hose staged nearby was also provided for hose stream protection for the construction site. These two water supplies and satisfies the requirement specified in NEIL Loss Control Standard section 5.3.14 which specifies that a water supply capable of furnishing greater of either 750 gpm or the largest fixed water-extinguishing system including 500 gpm for hose streams SHALL be available prior to combustibles being introduced on site. In addition, the fire water storage tank is capable of providing well beyond the required 2-hour duration of water supply for fire protection as required per section 5.3.14.2 [Ref:3].

(2) Automatic Fire Suppression:

In accordance with NEIL Loss Control Standard section 5.3.18. the fire suppression systems water supply, permanent stand pipes and hoses were installed in the Building X and placed into service prior to start of construction and the riser connection in the mechanical room and the Automatic Fire Suppression System attached to it was installed and placed into service prior to construction occupancy. In addition, freeze protection was provided for fire applicable suppression systems before November when temperatures in Waynesboro Georgia were expected to drop below 40°F [Ref:3].

(3) Fire Hose and Extinguishers-inspection:

Fire Hoses and portable fire extinguishers were staged prior for construction areas at designated locations (strategically near transient combustible areas, laydown areas, waste containers, and always near hot work enclosures) prior to the site being open for construction in accordance with 5.3.16.1, 5.3.16.2, 5.3.16.3, and 5.3.16.4, of the NEIL Loss Control Standard [Ref:3].

(4) Underground Water Mains and Hydrants:

One fire hydrant that provides water for the Fire Brigade and or Burke County Fire Department was installed prior to start of construction. This single fire hydrant is located 10 feet in front of building X. The fire hydrant is a standard fire hydrant with a 4-inch outlet and national pumper thread of 2 ½ inches. The single hydrant and hose equipment assures adequate overlap of protection for the previously mentioned wet pressurized standpipes in accordance with sections 5.3.15.1 and 5.3.15.2 of the NEIL Loss Control Standard. All underground water mains and hydrants were installed, completed, and in service prior to the start of construction in accordance with section 5.3.15.3 of the NEIL Loss Control Standard [Ref:3].

(5) Temporary Covering for Fire Protection Equipment:

All coverings placed over fire protection equipment for equipment protection purposes will be removed immediately following the completion of construction in accordance with section 3309 of the IFC [Ref:6].

(6) Emergency Telephones:

Readily accessible telephones shall be provided in approved locations on the construction site. Each phone will contain the street address for the construction site and the fire department emergency phone shall be affixed adjacent to the phone [Ref:6].

(7) On Site Construction Command Post:
In accordance with NFPA 241 an on-site command post was established. This location contains plans, emergency information, communications, keys and other equipment for use by both emergency responders and the fire protection engineer [Ref:7].

(8) Waste Disposal:
During construction waste was disposed of at the end of every shift in accordance with section 3304.2 of the IFC [Ref:6].

(9) Natural Hazards Protection:
Section 5.3.19 of NEIL Loss Control Standard was net by completion of the following. Buildings, structures, and sensitive equipment were designed, installed and secured based on environmental conditions depicted in the IBC and ASCE 7. A program was developed for temporary tie down for supports for lifting equipment and for equipment being placed when high winds would be anticipated. In addition, flood protection was provided for the 100-year level, when determining placement of all insured structures and for equipment and material laydown areas. The quantity of roofing material was limited to what could be secured during that shift. Lightning protection was installed in accordance with NFPA 780 for Building X as soon as it was feasible to be installed [Ref:3].

(10) Impairments and Reporting:
In accordance with Section 5.1.7.2 of the NEIL Loss Control Standard a procedure for documenting, reviewing, and notifying NEIL regarding impairments that last over 48 hours was created which required the fire protection engineer was notified [Ref:3].

(11)Temporary Structures and Components:
In accordance with section 5.1.8.3 information was submitted to NEIL for review and acceptance on the following subjects:

1. Use of temporary construction structures, enclosures, and trailers inside of permanent buildings. Information in regards to the on type of construction materials and fire protection to be utilized was provided.
2. The type of scaffolding and formwork (i.e., ordinary combustible or fire retardant). (Review covers only fire potential of scaffolding and formwork.) being used during construction.
3. Type of heating devices including those used on a temporary basis was provided.
4. A list and locations of fire extinguishers and temporary standpipes was provided.
5. Details on gas welding systems were provided.

7.0 Fire Safety During Demolition and Destruction
Gas and electric service was terminated and labeled where remaining in service. Standpipes and stairs within Building X were maintained. Temporary fire protection systems and fire barriers that provided protection for construction area were kept in place until permanent systems were operable and on line.

All unprotected openings in floors were sealed. Special precautions were taken to ensure all hazards such as oil-soaked floors or tanks that contained flammable or combustible liquids were removed or placed in acceptable areas behind barriers. No Asbestos was used during construction.

In accordance with Neil Loss Control Standard section 5.3.20.1 Insured Structures and Equipment are protected from demolition by barriers and automatic fire protection where the hazard deems it necessary per the applicable NEIL requirement. Per section 5.3.21 site security and fire watch walk downs were performed every hour to report possible fires and or any scrupulous activity. In addition, a fence was built around the construction site to establish a security and safety perimeter.

There were no exterior buildings where the content was in excess of 1 million dollars. All temporary buildings were separated from other structures by a minimum of 30 feet in accordance with NFPA 80A.

Potable fire extinguishers were provided for all exterior buildings and only UL approved fabrics were used for protective covering for equipment. All framing material used to support protective covering was made of non-combustible material.

All covered storage areas were located at least 30 feet from any permanent structure and protected from damage by all vehicular traffic by being located adequate distance from roadways.

In accordance with 5.3.26.1 the construction lay-down areas were located within 100 feet of the fire hydrant as was acceptable by NEIL.

In accordance with 5.3.26.2Two hose houses were located adjacent to hydrant and adequately equipped in accordance with NFPA 24.

In accordance with section 5.3.26.5 any idle pallets stored in the lay-down were stored in accordance with NFPA 1 and in accordance with section 5.3.26.6 piles of material and/or equipment in the lay-down area were kept to minimum levels and so that a minimum clear space of 30ft (9m) was maintained.

In accordance with section 5.3.26.9 stocks and/or supplies of flammable gases and liquids, combustible liquids, and/or lubricants were not stored in or within50 feet of the lay-down area [Ref:3].

An adequate number and size of charged hose lines were provided in accordance with NFPA 241 section 10.2.1 to provide protection where demolition work was performed in areas where floors were soaked with oil or other flammable liquid and where dust may have accumulated; or where combustible insulation was present in floors, walls, or ceilings/roofs where hot work was being performed [Ref:7].

A. Temporary Heating Equipment:

In accordance with NFPA 241 section 10.3.1 heat was maintained during building cold-weather demolition operations to allow the operation of sprinklers, hose, and extinguishers in areas not in the process of demolition. Minimum temperature of 4°C (40°F) was maintained at extremities with areas equipped with wet sprinkler systems in accordance with NFPA 241 section 10.3.2 and smoking was prohibited throughout demolition areas in accordance with NFPA 241 section 10.4*[Ref:7].

B. Demolition Using Explosives:

No explosives were allowed or used on site for demolition and or construction.

C. **Utilities:**

In accordance with NFPA 241 section 10.6.1 where possible electrical service was reduced to a minimum, and energized circuits were identified as ignition sources and logged according on the Fire Pre-Plan for that construction zone fire area.

D. **Gas:**

In accordance with NFPA 241 section 10.6.2.1 all gas supplies were turned off and capped at a point outside the building prior to demolition and gas lines within the building were purged in accordance with NFPA 241 section10.6.2.2 [Ref:7].

E. **Fire Cutoffs:**

Per NFPA 241 section 10.7.1 Vertical and horizontal cutoffs were retained until razing operations necessitated their removal as permitted by the Fire Protection Engineer in consort with NEIL.
In accordance with NFPA 241 section 10.7.2 Fire doors were secured closed at the end of each working day.

F. **Fire Protection During Demolition**:

The permanent Automatic Sprinkler System, which was the first system built and put into service, for Building X will remain operable in accordance with NFPA 241 section 10.8.2. in addition, the operation of sprinkler control valves was only permitted by a work order signed off by the fire protection engineer and performed by a technician in accordance with NFPA 241 section 10.8.3.1. Per section 10.8.3.2 of NFPA 241 when the sprinkler protection was regularly turned off and on to facilitate removal and capping of segments, the sprinkler control valves were checked and the position verified per surveillance at the end of each work shift to ascertain that protection is in service.

In accordance with NFPA 241 section 10.8.4 were maintained in conformity with the progress of demolition to ensure the system was operable when and if required. Per NFPA241 section 0.8.5* fire extinguishing equipment was staged in locations designated by the fire protection engineer and document on the Fire Pre-Plans.
No underground Operations were conducted at this construction site. The Fire Response Procedures and Evacuation Plans which were used for construction and were addressed previously in sections 5.0 III and 5.0 II respectively were also used for demolition for the construction site for Building X[Ref:7].

Since NEIL is the insurer of Building X and its construction site the NEIL Loss Control Standard supersedes but references all applicable NFPA and IBC codes. In addition, the International Fire Code was used for recommendation purposes and to cover deltas that the NEIL Loss Control Standard may not have covered.

APPENDIX C

The Diesel split case centrifical fire pump system components are as follows:

ITEM NO.	DESCRIPTION	QTY
1	HORIZONTAL SPLIT CASE FIRE PUMP	1
2	OS&Y GATE VALVE 8"	1
3	8" WAFER CHECK VALVE	3
4	BUTTERFLY VALVE W/ TAMPER SWITCH 6"	2
5	HOSE HEADER MANIFOLD	1
6	2 1/2" HOSE VALVE	3
7	BUTTERFLY VALVE W/ TAMPER SWITCH 8"	4
8	AIR RELEASE VALVE	1
9	MAIN RELIEF VALVE 4"	1
10	JOCKEY PUMP	1
11	OS&Y GATE VALVE 1 1/4"	2
12	CHECK VALVE 1 1/4"	1
13	ALTITUDE VALVE 6"	1
14	BACKFLOW PREVENTER 8"	1
15	SYSTEM BASE	1
16	DIESEL CONTROLLER	1
17	JOCKEY PUMP CONTROLLER	1
18	DOUBLE WALL FUEL TANK 250 GALLON	1
19	FUEL CATCH BASIN	1
20	BATTERY RACK	1
21	DOUBLE WALK DOORWAY	1
22	EXHAUST FAN	1
23	COMBUSTION LOUVER	1
24	VENTILATION LOUVER	1
25	MINI POWER ZONE	1
26	UNIT HEATER W/ THERMOSTAT	1
27	DOGHOUSE	1
28	FIRE ALARM PANEL	1

References

[1] 2009 Edition, NFPA 101 Life Safety Code (LSC) Multiple Sections

[2] 20th Edition, NFPA Fire Protection Handbook, Vol. 1, Multiple Sections

[3] 20th Edition, NFPA Fire Protection Handbook, Vol. 2, Multiple Sections

[4] 2009 International Business Code (IBC), Multiple Sections

[5] September, 2010 NEIL Loss Prevention Control Manual Multiple Sections

[6] SFPE Handbook of Fire Protection Engineering, 4th Edition, Multiple Sections

[7] 2009 Edition, NFPA 101 Life Safety Code (LSC) Handbook, Multiple Sections

[8] International Building Code 2006 Edition, Multiple Sections

[9] Society of Fire Protection Engineers, 4th Edition 2008. SFPE Handbook of Fire, Multiple Sections

[10] ibid; Table 2-6.B1 "Tenability Limits for Incapacitation on or Death from Exposures to Common Asphyxiant Products of Combustion".

[11] NUREG-1934 EPRI 1023259 Nuclear Power Plant Fire Modeling Application Guide (NPP FIRE MAG); Electric Power Research Institute

[12] Fire Probabilistic Risk Assessment Methods Enhancements Appendix G (Section G.3.3) of EPRI 1011989, NUREG/CR-6850

[13] Characterization of Firefighter Smoke Exposure Fire Technology 2011 Springer Science+Business Media, LLC. Manufactured in The United States DOI: 10.1007/s10694-011-.0212-2.

[14] 2012 International Fire Code

[15] 2013 NFPA 241Edition Standard for Safeguarding Construction, Alteration, And Demolition Operations.